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TRECOM TECHNICAL REPORT 63-75

INVESTIGATION OF ELASTIC COUPLING PHENOMENA OF HIGH SPEED RIGID ROTOR SYSTEMS

Task 1D121401A14302
(Formerly Task 9R38-13-014-02)
Contract DA 44-177-TC-828

June 1964

prepared by:

LOCKHEED-CALIFORNIA COMPANY
Burbank, California

HEADQUARTERS
U S ARMY TRANSPORTATION RESEARCH COMMAND
FORT EUSTIS VIRGINIA

This report has been reviewed by the U. S. Army Transportation Research Command and is considered to be techn' ally sound. The report is published for the exchange of information and stimulation of ideas.

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INVESTIGATION OF ELASTIC COUPLING PHENOMENA OF HIGH SPEED RIGID ROTOR SYSTEMS

Lockheed Report No. 17013

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for

U. S. ARMY TRANSPORTATION RESEARCH COMMAND

FORT EUSTIS, VIRGINIA

PREFACE

This report describes an analytical and experimental investigation of rigid rotor dynamics conducted with the cooperation of the NASA Langley Research Center by the Lockheed-California Company. The program was sponsored by the U.S. Army Transportation Research Command, Fort Eustis, Virginia, under the technical monitorship of Messrs. J.E. Yeates and R.D. Powell.

The program began in April 1962 and was completed in June 1963. NASA personnel associated with the program included Messrs. F. Gustafson, J. Ward, R. Houston, and R. Bennett. The Lockheed personnel included Messrs. I. Culver, L. Celniker, T. Hanson, J. Kanno, S. Lundgren, R. Donham, and S. Kiser. The Lockheed portion of the program was directed by Mr. P.W. Theriault, Assistant Chief Engineer, Advanced Systems Research.

Thanks are due to TRECOM and the NASA Langley Research Center for their support in providing the wind tunnel facilities for the experimental parts of the program and for their help and advice in planning and conducting the program.

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ILLUSTRATIONS

ILLUSTRATIONS

(Continued)

ILLUSTRATIONS
(Continued)

LIST OF TABLES

SYMBOLS

B_0, E	Blade flapwise and blade in-plane static displacement outboard of feathering bearing
b	Pre-cone angle
c	Blade-section chord
f_θ	Damping coefficient
GR	Gear ratio $\frac{R_B}{R_G}$ (see sketch 2)
g	Acceleration of gravity
I_H	Blade horizontal mass moment of inertia $\iiint \sigma^2 \, dm$
I_V	Blade vertical mass moment of inertia $\iiint \tau^2 \, dm$
I_g	Control gyro mass moment of inertia
I_β	Blade flapwise mass moment of inertia $\iiint \rho^2 \, dm$
K_g	Cyclic control gyro stiffness
K_β	Blade flapping stiffness
k_{β_0}	Blade flapping stiffness outboard of feathering bearing
k_ϵ	Blade in-plane stiffness outboard of feathering bearing
k_θ	Total blade torsional spring constant
k_θ	Blade aerodynamic damping coefficient
L, M	Rolling moment, pitching moment
L_g, M_g	Control gyro rolling moment and pitching moment
M_θ	Blade feathering moment
m	Blade mass density
M_θ^θ	Blade feathering moment derivative due to rate of blade displacement
n	Load factor
Q_θ	Sum of generalized external forces and forces derivable from potential and dissipative functions
q_1	Collective component depicting fundamental blade flapping displacement
q_2, q_3	Cyclic cartesian components depicting fundamental blade flapping displacement
R	Blade radius
R_B, R_G	Control gyro linkage geometry (see sketch 2)

SYMBOLS
(Continued)

r_1	Collective component depicting fundamental blade in-plane bending displacement
r_2, r_3	Cyclic cartesian components depicting fundamental blade in-plane bending displacement
T	Blade total kinetic energy
V_M $V_{MODEL} = V_M$	Velocity of model in air medium
$V_{SIMULATED}$	Velocity of simulated vehicle derivable from model in air medium or freon medium
V_{M_F}	Velocity of model in freon medium
x, y, z	Cartesian components of body non-rotating coordinate system
x_r, y_r, z_r	Cartesian components, perpendicular to rotor shaft, of rotor hub translational displacement
z_g	Relative vertical displacement of swash plate
α	Rotor angle of attack
β_o, ϵ	Blade flapwise and blade in-plane total displacements outboard of feathering bearing
θ	Blade-section pitch angle
$\bar{\theta}, \bar{\beta}_o, \bar{\epsilon}$	Blade feathering, flapping and in-plane total perturbational displacements outboard of feathering bearing
λ	Blade sweep relative to feathering bearing axis
μ	Advance ratio
ρ, σ, τ	Blade principal axes
ρ_r, σ_r, τ_r	Blade principal axes relative to portion of blade inboard of feathering bearing
ρ_f, σ_f, τ_f	Blade principal axes relative to portion of blade outboard of feathering bearing
ϕ_c, θ_c	Roll and pitch displacements consistent with x_r, y_r, z_r
ϕ_g, θ_g	Roll and pitch displacements of control gyro
ψ	Blade azimuth angle
Ω	Rotor angular velocity

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I. SUMMARY

This report describes an investigation of the effects of variations in design parameters on the dynamic characteristics of cantilever blade or "rigid" rotors.

Some fundamental concepts of rigid rotor dynamics including decoupling are presented, as well as a 10-degree-of-freedom rotor stability analysis in hovering and a brief study of the static stability of the model.

A dynamic helicopter wind tunnel model having a 10-foot rotor diameter was constructed with three sets of blades and a hub which allowed many variations in geometry and stiffness. Seven rotor configurations were tested in the NASA Langley Full Scale Tunnel (FST), and two of these were tested to higher speeds and full scale Reynolds number and Mach number in the NASA Langley Transonic Dynamics Tunnel (TDT).

The model and rotors and the testing technique are described, and all the data collected are included. Only those portions of the data which appeared to be of particular interest are reduced and presented.

A principal focus of the program was the decoupled, or "matched blade", type of rigid rotor. It was demonstrated to simulated air speeds on the order of 240 miles per hour that this type of rotor is stable with extremely small values of control gyro inertia. In addition, it was found that blade matching has a major influence on chordwise oscillating blade loads. Figures 1 and 2 show that first (cantilever bending) mode matched blade chord loads are about one-third as large as those for coupled or chord-stiff blades and that chord loads for all-mode-matched blades are only about one-tenth as great as for coupled blades. These approximate ratios apply over the entire range of forward velocities tested. The alphabetic designations on these figures are the test configuration identifications.

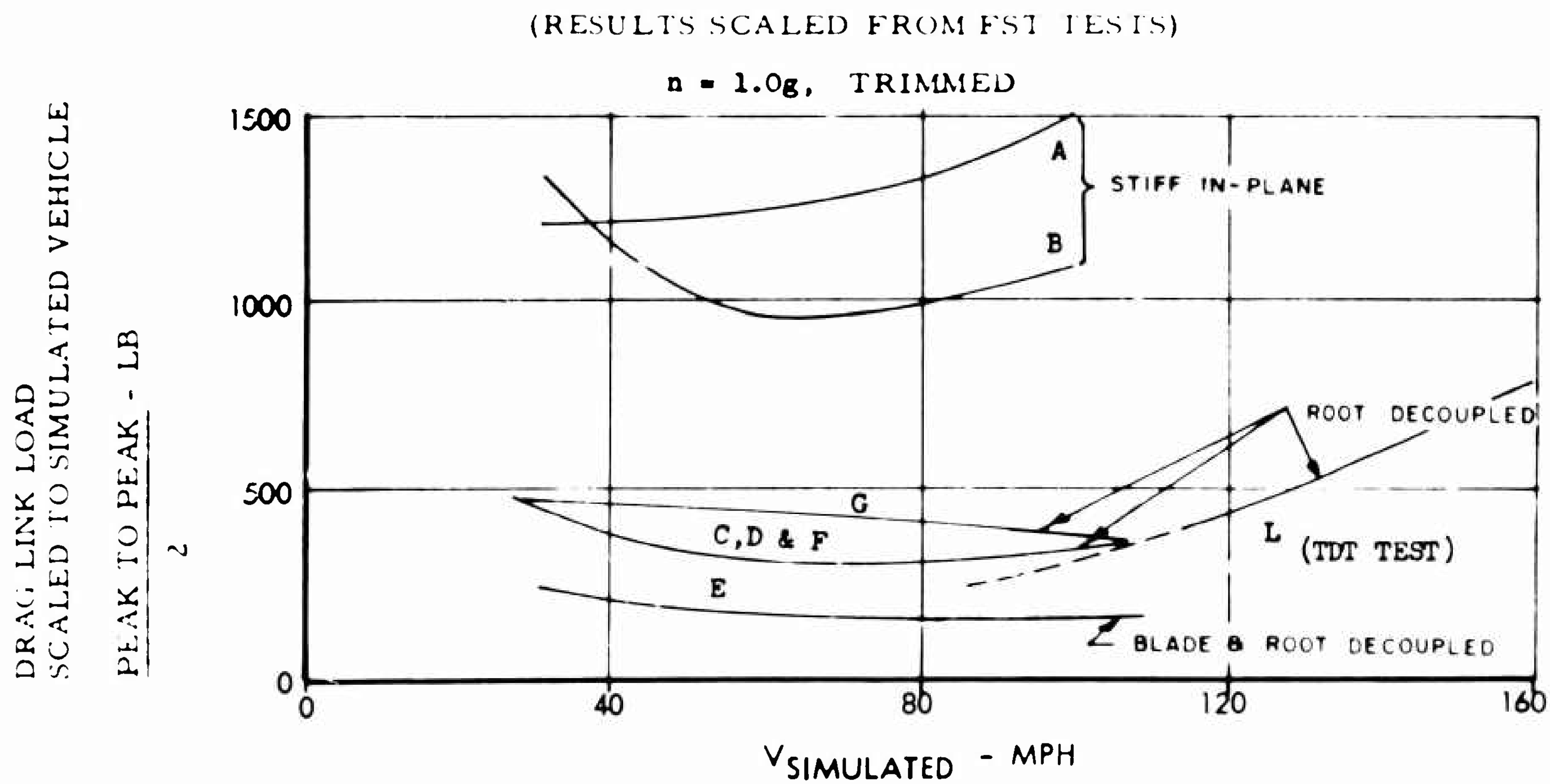


FIGURE 1 DRAG LINK LOAD SUMMARY CURVES

(RESULTS SCALED FROM TDT TEST)
NOTE: FULL SCALE REYNOLDS NUMBER AND
MACH NUMBER MATCHED

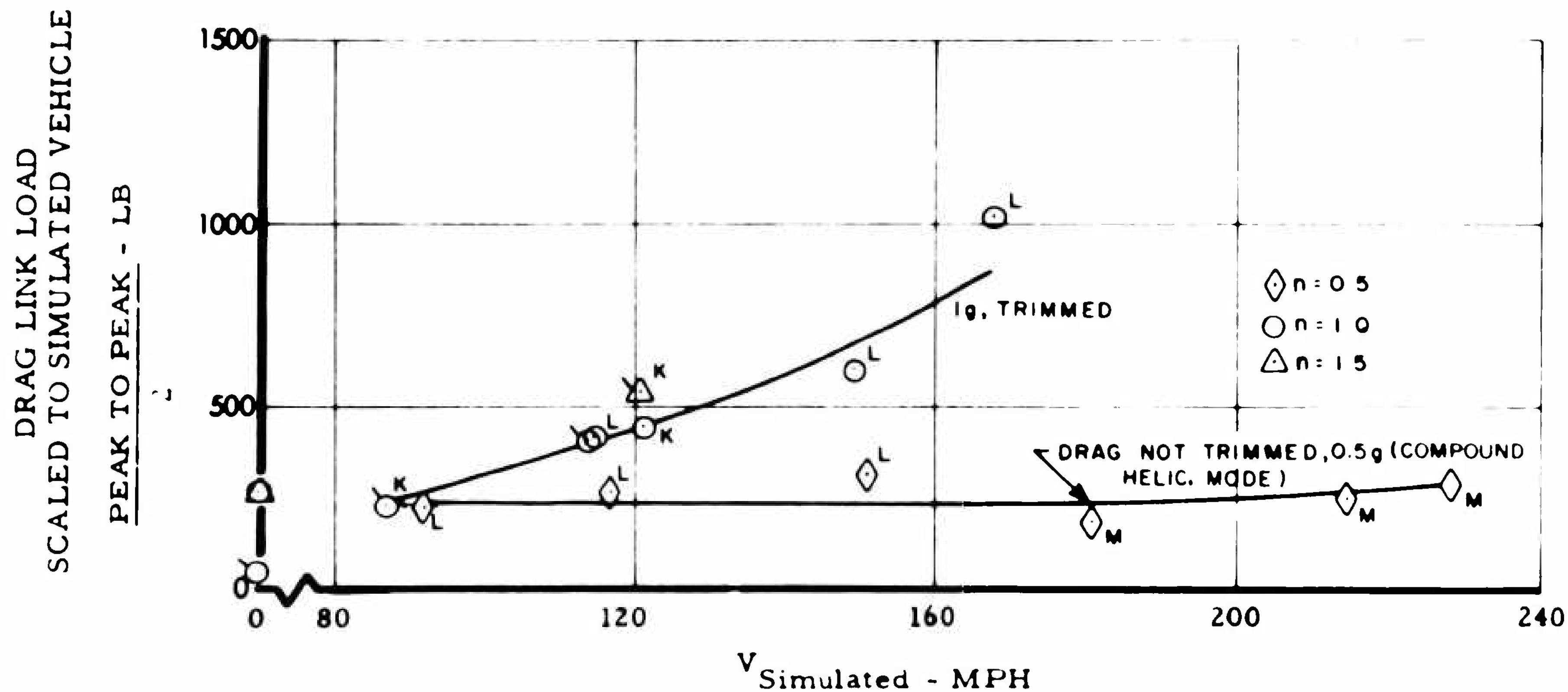


FIGURE 2 DRAG LINK LOAD SUMMARY CURVES
MATCHED BLADE SYSTEMS

II. CONCLUSIONS AND RECOMMENDATIONS

ROTOR LOADS

Blade drag link oscillating loads (chordwise bending at approximately 10 per cent radius) are summarized in Figures 1 and 2. These have been scaled for the simulated vehicle from the model results given in Figures 31 and 33 for the configurations listed in Table 3, Page 59.

Configurations "A" and "B" were coupled or chord-stiff rotors with 0° twist and -8° twist respectively, and they showed the highest chord loads, by far, of all the configurations tested. Configuration "E" was the fiberglass blade configuration where an attempt was made to achieve an all-mode-matched or decoupled blade by matching the flapwise and chordwise blade stiffness, inch by inch, along the span of the blade. This configuration showed, by far, the lowerst chord loads, which were on the order of 10 per cent as large as for the coupled blades. All the other configurations were matched only in their first mode or cantilever bending stiffness by the insertion of a soft drag link at the root of an otherwise chord-stiff blade. These first-mode-matched rotors showed chord loads about one-third as large as for the coupled or chord-stiff blades and about two or three times larger than for the all-mode-matched blades. From this it can be concluded that blade matching, involving reduced chord stiffness, is a powerful tool for reducing the chordwise loads generated in the blades (and subsequently fed into the helicopter).

Blade-to-gyro pitch link oscillating loads (blade root feathering torsion) are summarized in Figures 32 and 33 for the configurations listed in Table 3. The large magnitude of the oscillating pitch link load (which is primarily a steady gyro trim moment in the non-rotating part of the control system) was not anticipated. Examination of the oscillograph records showed a phase difference of about 90° (±10°) between the point of maximum link load and the point of maximum feathering angle amplitude. This phasing indicated that the load was principally a feathering friction or aerodynamic damping type of load. Further examination of the records showed that most of the torque measured at the pitch link was also present in the blade torsion measurement at radial station 22 and therefore must be generated in the outboard portion of the blade. Equation 28 of Section IV gives the blade feathering aerodynamic damping, which is shown to be a function of blade chord to the third power and tip speed to the second power. The results obtained when utilizing this equation to calculate the theoretical first harmonic pitch link load due to aerodynamic damping are shown on the curves of Figure 6, Page 25. In this figure, the measured pitch link loads are compared to the theoretical loads due to aerodynamic damping for three rotor configurations, and it is seen that most of the pitch link load is aerodynamic damping. Additional damping due to friction in the feathering bearings or in the rotating part of the control system would tend to displace the theory curves vertically into even better agreement with the data. Figure 6 also shows a scatter band for data from the same configuration of as much as 10 pounds.

In the pitch link load summary curve (Figure 32), all the data fall within a load band about 20 pounds in width. From Figure 6 it could be inferred that 10 pounds of this band could be data scatter. In light of the above situation, it can only be concluded that:

1. Most of the link load is due to aerodynamic damping and is primarily a function of tip speed to the second power and blade chord cubed.

2. Slight differences between pitch link loads for different configurations could have been data scatter due to slight differences in frictions, etc.

3. All data fall within a fairly constant width band and therefore none of the configuration variations caused gross changes in the basic pitch link load trend with velocity.

MODEL VIBRATION LEVELS

Unfortunately, velocity pickups of very wide frequency range were used to measure body vibration in the FST tests. These instruments recorded a great deal of "hash" or vibration at very high frequencies. A major portion of this "hash" occurs at the first harmonic of the rotational speed of the synchronous electric motors. This "hash" makes meaningful reduction and analysis of the data very questionable. Because of this, the data is presented as peak-to-peak oscillations in velocity, with no attempt to sort out meaningful harmonics. The problem is compounded by the impossibility of achieving the same base level of vibration due to rotor unbalance or maltrack on seven rotor configurations when as many as three configurations were run in one day. For instance, the glass blade configuration shows high vibration levels which may reflect nothing more than the difficulty that was experienced in achieving good track with a set of blades that were extremely soft in torsion. In the FST tests, the body lateral was the only vibration pickup which showed sufficient difference between configuration that any meaningful interpretation might be attempted. The twisted metal matched blade configuration with the low gyro inertia showed the lowest vibration. At 106 miles per hour, the various matched, twisted blade configurations showed lower vibration than the chord-stiff or unmatched rotors.

In the TDT, accelerometers were used to record vibration rather than velocity pickups and the results were somewhat more useful, although once again the frequency range was wider than necessary and some "hash" was present. Again the "hash" shows strong first harmonic content of the rotational speed of the synchronous electric motors. Vibration levels of the two matched blade configurations tested in the TDT are rather high in hover, perhaps due to recirculation and wall effects from hovering a 10-foot rotor in a 16- by 16-foot cross section. The lateral and longitudinal vibration levels dropped slightly below the hover vibration levels at 100 miles per hour and came back up to hover vibration level at about 140 miles per hour. The vertical vibration was at hovering level up to 100 miles per hour and began to rise quite rapidly thereafter.

In both the FST and TDT tests, the second flap bending frequencies of the rotor blades which were tested were near 3P. This proximity in a three-blade rotor system is certain to result in higher vibration levels than would have been measured had this characteristic been designed out of the rotor system. Plots of the uncoupled blade bending frequencies versus rotor r.p.m. are given on pages 46 and 47. However, since vibration in a helicopter body is simply the body response to the oscillating loads generated by the rotor, it can be assumed that reductions in the oscillating loads generated by the rotor should yield an improvement in helicopter vibration levels. It is believed, therefore, that the substantial reduction in oscillating chord loads demonstrated by the matched blade rotor configurations represents a potential improvement in helicopter vibration levels.

STABILITY

The stability investigation of the model in the freon tunnel presented in Section IV was conducted as a safety measure for the wind tunnel program and is not directly applicable to the stability of a free flight vehicle. The free flight vehicle will, in general, be more stable than the wind tunnel model. The model was, however, demonstrated to be stable at simulated air speeds up to 240 miles per hour.

The dynamic stability of the blade gyro combination was investigated analytically and is shown in Section IV to be satisfactory with extremely small values of gyro inertia for the matched blade rotor. This analysis was verified experimentally when tests to 240 miles per hour simulated air speeds with very small gyro inertia values showed no indication of any instability.

RECOMMENDATIONS

This program has shown that the matched blade or possibly reduced chord stiffness type of rigid rotor has substantially lower gyro size and much lower oscillating chordwise loads than the coupled (or chord-stiff) type of rigid rotor. The matched rotor configurations tested were not optimum or even near optimum designs for two reasons. First, the requirement for many types of geometry and stiffness variation required rather unusual hub and blade designs. Second, the high solidity per blade resulted in large blade chords and therefore very large aerodynamic control forces. A practical helicopter of such high solidity would undoubtedly utilize a larger number of blades of smaller chord. Lowering the chord quickly reduces the level of blade stiffness far below those tested in this program.

It is therefore recommended that additional test work be undertaken with a matched blade configuration using an optimized production type hub and blade design with a radius to chord ratio on the order of 16 in place of the value of 8 used in this program. Solidities representative of high-speed rotor systems would then be achieved with additional numbers of blades.

III. INTRODUCTION

A revival of interest in recent years in the unique capabilities of the "rigid" or cantilever blade rotor has created a need for a better understanding of the dynamics of this type of rotor.

Lockheed has been conducting a continuous program of analytical investigation of rigid rotor dynamics since 1958. By 1961, a considerable body of theory had been developed and a few basic configuration ideas had been tested on the Lockheed CL-475 test bed helicopter in hovering and low-speed forward flight. Recognizing the high costs and risks involved in exploratory dynamic testing into unknown areas on a full-scale flight vehicle, Lockheed proposed to the U.S. Army Transportation Research Command and the NASA Aerospace Mechanics Division a joint program of wind tunnel testing of a 10-foot-diameter dynamic model of a rigid rotor helicopter.

A broad program of testing was drawn up involving hovering testing and "debugging" of the model at Lockheed's Burbank plant, testing in air up to simulated air speeds of 127 miles per hour in the NASA Full Scale Tunnel at Langley, and testing to full-scale Reynolds and Mach numbers at air speeds up to 230 miles per hour by use of the Freon atmosphere in the NASA Transonic Dynamics Tunnel at Langley. Figures 3 and 4 show installation of the model in each tunnel. Variations in the following parameters were included in the program:

a. Hub flapping stiffness

b. Blade first mode (cantilever) chord stiffness

c. Blade chord stiffness distribution

d. Blade sweep angle

e. Control gyro inertia

f. Load factor

g. Rotor tip speed

h. Blade twist

i. Blade/gyro mechnaical ratio

Variations provided for but not tested were:

j. Gyro cant angle

k. Tip weight mass

The inclusion of this amount of variation capability in one basic hub and gyro required a "mechano-set" approach to building up the various configurations and resulted, unfortunately, in an aerodynamically rather "dirty" (high drag) hub area.

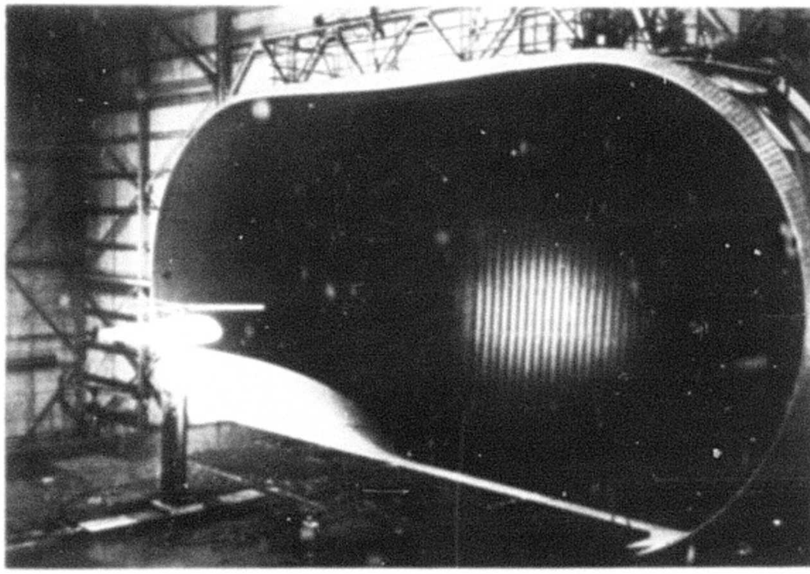


FIGURE 3 MODEL IN LANGLEY FULL SCALE TUNNEL

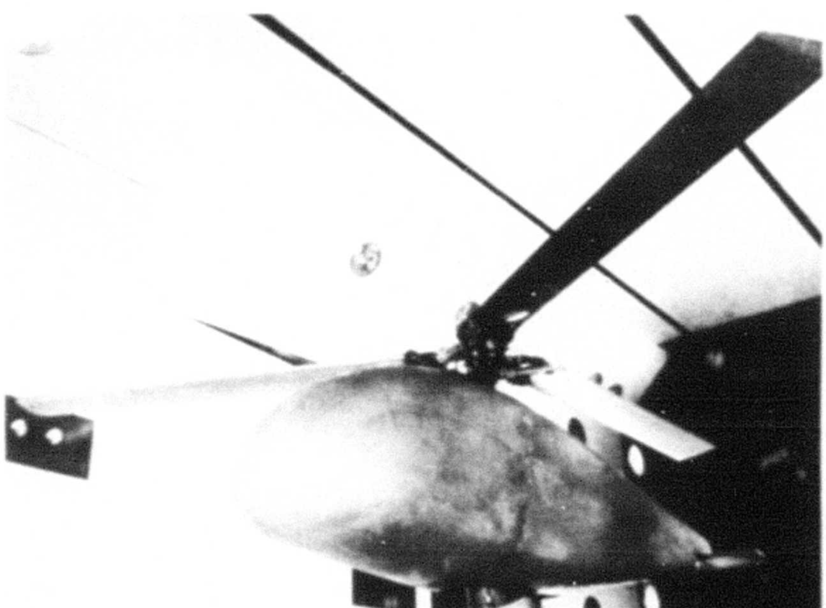


FIGURE 4 MODEL IN LANGLEY TRANSONIC DYNAMICS TUNNEL

The desire to carry the testing into areas of high Mach number and advance ratios dictated a rotor solidity of .12.

One of the principal areas of interest in the program was the "matched blade" configuration where the non-rotating blade chord stiffness in the board of the feathering bearings is equal to the flap stiffness in the same area. Analysis has shown that this type of rigid rotor should have lower oscillating load inputs to the hub, thereby resulting in lower vibration levels and lower blade stres stresses. In addition, the matched blade appeared to be stable with a much smaller gyro, thus reducing maneuver control forces and allowing an aerodynamic clean-up of the gyro. Hovering stability solutions for the untwisted metal rotor for both the high in-plane and matched blade systems with various gyro sizes predict this smaller gyro possibility. These results are published in reference 3. Whirl tower experience with the CL-475 rotor, a high in-plane system, had shown a lower limit on gyro size as might be expected from the results of the referenced analysis (Figure 5). The construction of matched blades also appeared to offer the possibilities of greatly reduced blade weights.

FIGURE 5 BURBANK WHIRL TEST

IV. ANALYTICAL CONSIDERATIONS

A study of the stability and control characteristics of a free-feathering rigid rotor helicopter must consider all degrees of freedom having frequencies in the range below two per revolution. The possibility of high-frequency rotor blade flutter is not considered here since the general practice of mass balancing at least the outboard two-thirds of the rotor blade at or near the quarter chord virtually eliminates this from further consideration.

The fuselage, control gyro, and rotor disc make up a convenient conceptualization of the system. The fuselage provides a means of describing the displacements and angular motions of the helicopter and in particular, for the case of static behavior, the angle of attack of the helicopter. The control gyro and the rotor disc provide convenient conceptualizations of the feathering motion and the flapping and in-plane elastic deformations of the rotor blades, respectively. Cyclic flapping of the blades depicts the pitch and roll of the rotor disc, while collective flapping describes the vertical translation. Blade motions in the plane of the rotor disc are consistent with collective and cyclic in-plane motions.

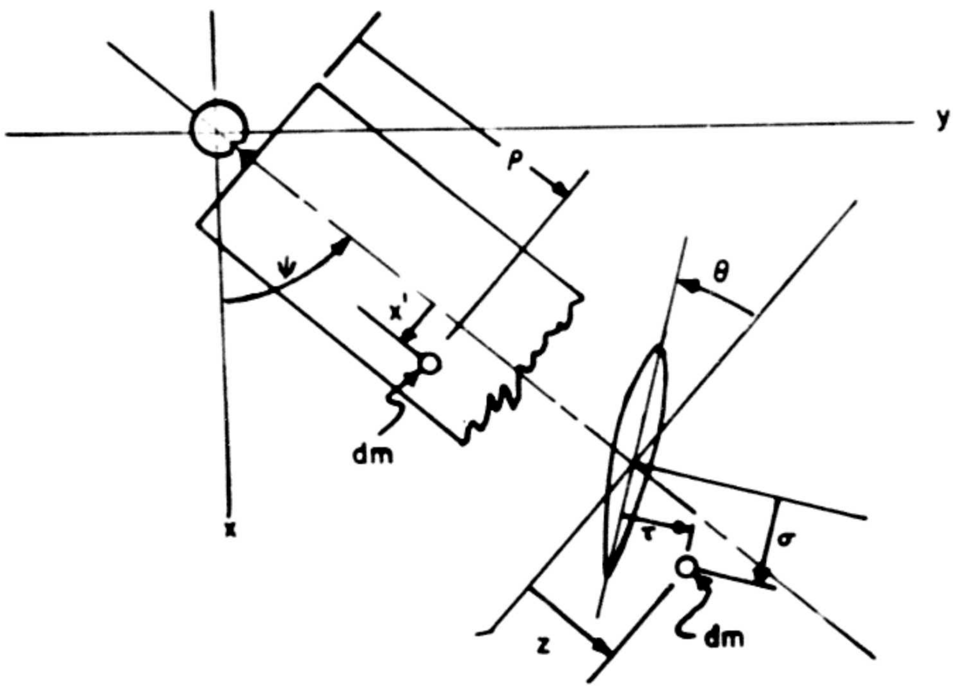
The subsequent discussion is divided into three parts: (A) derivation of control gyro equilibrium equations, showing effects of compliance correction and elastic decoupling (matching) of rotor blades, and indication of salient factors influencing stability and control; (B) static stability of the wind tunnel model; and (C) analysis of dynamic stability in hovering.

(A) CONTROL GYRO EQUILIBRIUM EQUATION

It is postulated that moment inputs into the control gyro result from feathering and elastic deformation of the blades. Furthermore, the linkage between the blades and the control gyro is such that moments about the blade feathering axis are reacted by the control gyro. All other moments developed in the blade system are reacted by the rotor mast. The linkage which transmits the moment into the control gyro is described in terms of the cant angle, defined as the azimuth angle between the blade feathering axis and its attachment point to the control gyro; and the gear ratio, defined as the ratio of blade feathering angle to control gyro angle. Subsequent discussion of the control gyro equilibrium equation is divided into (1) moments resulting from blade feathering motion and (2) gyro moments resulting from elastic deformation of the blades.

(1) MOMENTS RESULTING FROM BLADE FEATHERING MOTION

The moments on the control gyro resulting from blade feathering are determined using the schematic model depicted in Sketch 1.



SKETCH 1

A rotor blade is at an azimuth angle ψ in the x - y plane of the x, y, z coordinates system fixed in space. An element of mass, dm, of the blade with ρ , σ , τ coordinates will have the following coordinates in the x, y, z plane:

$$
\begin{aligned}
x &= \rho \cos\psi + x' \sin\psi \\
y &= \rho \sin\psi - x' \cos\psi \\
z &= \sigma \sin\theta + \tau \cos\theta \\
\text{where } x' &= \sigma \cos\theta - \tau \sin\theta
\end{aligned}
\qquad (1)
$$

Therefore,

$$
\begin{aligned}
x &= \rho \cos\psi + \sigma \cos\theta \sin\psi - \tau \sin\theta \sin\psi \\
y &= \rho \sin\psi - \sigma \cos\theta \cos\psi + \tau \sin\theta \cos\psi \qquad (2) \\
z &= \sigma \sin\theta + \tau \cos\theta \, .
\end{aligned}
$$

The rates of motion of dm in the x, y, z planes are found by differentiating equation (2), giving

$$
\begin{aligned}
\dot{x} &= -\rho\dot{\psi} \sin\psi - \sigma\dot{\theta} \sin\theta \sin\psi + \sigma\dot{\psi} \cos\theta \cos\psi - \tau\dot{\theta} \cos\theta \sin\psi \\
&\quad - \tau\dot{\psi} \sin\theta \cos\psi \\
\dot{y} &= \rho\dot{\psi} \cos\psi + \sigma\dot{\theta} \sin\theta \cos\psi + \sigma\dot{\psi} \cos\theta \sin\psi + \tau\dot{\theta} \cos\theta \cos\psi \qquad (3) \\
&\quad - \tau\dot{\psi} \sin\theta \sin\psi \\
\dot{z} &= \sigma\dot{\theta} \cos\theta - \tau\dot{\theta} \sin\theta \, .
\end{aligned}
$$

The kinetic energy, dT, of the elemental mass, dm, is therefore

$$
\begin{aligned}
dT &= 1/2 \, dm \, (\dot{x}^2 + \dot{y}^2 + \dot{z}^2) \\
&= 1/2 \, dm \, (\rho^2 \dot{\psi}^2 + \sigma^2 \dot{\theta}^2 + \sigma^2 \dot{\psi}^2 \cos^2\theta + \tau^2 \dot{\theta}^2 + \tau^2 \dot{\psi}^2 \sin^2\theta \\
&\quad + 2\rho\sigma \dot{\psi}\dot{\theta} \sin\theta + 2\rho\tau \dot{\psi}\dot{\theta} \cos\theta - 2\sigma\tau \dot{\psi}^2 \sin\theta \cos\theta) \, , \qquad (4)
\end{aligned}
$$

which, after integration, will result in the total kinetic energy of the blade.

The following nomenclature is adopted for inertial quantities:

$$
\begin{aligned}
&\iiint \sigma^2 \, dm = I_H \quad \text{(called the "horizontal inertia")} \\
&\iiint \tau^2 \, dm = I_V \quad \text{(called the "vertical inertia")} \qquad (5) \\
&\iiint \rho^2 \, dm = I_\beta \, .
\end{aligned}
$$

For a mass balanced blade, the products of inertia

$$
\iiint \rho\tau \, dm = \iiint \tau\sigma \, dm = 0 \, . \qquad (6)
$$

In order to provide for sweep of the mass axis of the blade relative to the feathering axis, let

$$\sigma = \sigma' + \rho \lambda . \tag{7}$$

Where σ' is the distance of an elemental mass, dm, from the mass axis, measured parallel to the chord of the blade, and λ is the sweep angle, then

$$\iiint \rho \sigma \, dm = \iiint (\sigma' + \rho\lambda) \, dm = \lambda I_\beta . \tag{8}$$

Therefore, in terms of equations (5) and (8), the total kinetic energy of the blade, obtained by integration of equation (4), becomes

$$T = 1/2 \left[I_\beta \dot{\psi}^2 + I_H \dot{\theta}^2 + I_H \dot{\psi}^2 \cos^2\theta + I_V \dot{\theta}^2 + I_V \dot{\psi}^2 \sin^2\theta + 2\lambda \, I_\beta \dot{\psi}\dot{\theta} \sin\theta \right] . \tag{9}$$

The equation of motion of the blade in the θ direction can be derived using Lagrange's equation in the form

$$\frac{d}{dt}\left(\frac{\partial T}{\partial \dot{\theta}}\right) - \frac{\partial T}{\partial \theta} = Q_\theta \tag{10}$$

where Q_θ is the sum of generalized external forces and forces derivable from potential and dissipative functions, and will be expressed in the following manner:

$$Q_\theta = M_\theta - \left[k'_\theta + \frac{2}{3}\left(\frac{R_B}{R_G}\right)^2 K_g \right] \theta - f_\theta \dot{\theta} . \tag{11}$$

M_θ will denote net reactive forces at the root of the blade, and the balance of Q_θ will be assumed to be expressible in terms of spring and damping terms as indicated in the last two terms of Equation (11). For the sake of brevity, the second term of Equation (11) will be referred to as $k_\theta \theta$.

Since the rotational speed of the blade is constant, $\dot{\psi} = \Omega$ and $\ddot{\psi} = 0$, so that Equations (9), (10) and (11) result in

$$(I_H + I_V)\ddot{\theta} + (I_H - I_V)\Omega^2 \sin\theta \cos\theta + f_\theta \dot{\theta} + k_\theta \theta = M_\theta . \qquad (12)$$

Employing small angle assumptions such that $\sin\theta = \theta$ and $\cos\theta = 1$, Equation (12) yields

$$(I_H + I_V)\ddot{\theta} + (I_H - I_V)\Omega^2 \theta + f_\theta \dot{\theta} + k_\theta \theta = M_\theta . \qquad (13)$$

In terms of cyclic feathering expressed as

$$\theta = -\frac{R_G}{R_B}\theta_g \cos(\psi + \gamma)$$

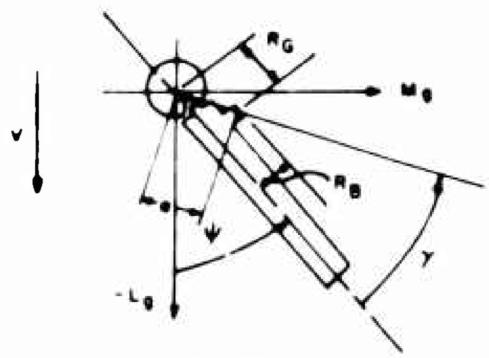
$$\dot{\theta} = \frac{R_G}{R_B}\theta_g \dot{\psi} \sin(\psi + \gamma) = \frac{R_G}{R_B}\theta_g \Omega \sin(\psi + \gamma) \qquad (14)$$

$$\ddot{\theta} = \frac{R_G}{R_B}\theta_g \Omega^2 \cos(\psi + \gamma)$$

where θ_g is the pitch angle of the control gyro, Equation (13) yields

$$-(k_\theta - 2I_V\Omega^2)\frac{R_G}{R_B}\theta_g \cos(\psi+\gamma) + f_\theta \frac{R_G}{R_B}\Omega\,\theta_g \sin(\psi+\gamma) = M_\theta . \qquad (15)$$

The resolution of rolling and pitching moments (i.e., L_g and M_g) applied to the control gyro by a single blade, as shown in Sketch —, yields



SKETCH

$$L_{g_1} = -M_\theta \frac{R_G}{R_B} \sin(\psi+\gamma) = \left(\frac{R_G}{R_B}\right)^2 (k_\theta - 2I_V\Omega^2)\ \theta_g \sin(\psi+\gamma)\cos(\psi+\gamma) - f_\theta \left(\frac{R_G}{R_B}\right)^2 \Omega\theta_g \sin(\psi+\gamma)\sin(\psi+\gamma)$$

$$M_{g_1} = -M_\theta \frac{R_G}{R_B} \cos(\psi+\gamma) = \left(\frac{R_G}{R_B}\right)^2 (k_\theta - 2I_V\Omega^2)\ \theta_g \cos^2(\psi+\gamma) - f_\theta \left(\frac{R_G}{R_B}\right)^2 \Omega\ \theta_g \sin(\psi+\gamma)\cos(\psi+\gamma)$$

Then the resultant of three blades can be expressed as

$$L_g = L_{g_1} + L_{g_2} + L_{g_3}$$

$$= \left(\frac{R_G}{R_B}\right)^2 (k_\theta - 2I_V\Omega^2)\ \theta_g \sum_{1=1}^{3} \sin\left(\psi+\gamma+\frac{2\pi}{3}1\right)\cos\left(\psi+\gamma+\frac{2\pi}{3}1\right)$$

$$-f_\theta \left(\frac{R_G}{R_B}\right)^2 \Omega\ \theta_g \sum_{1=1}^{3} \sin^2\left(\psi+\gamma+\frac{2\pi}{3}1\right)$$

$$M_g = M_{g_1} + M_{g_2} + M_{g_3}$$

$$= \left(\frac{R_G}{R_B}\right)^2 (k_\theta - 2I_V \Omega^2)\, \theta_g \sum_{i=1}^{3} \cos^2 \left(\psi + \gamma + \frac{2\pi}{3} i\right)$$

$$-f_\theta \left(\frac{R_G}{R_B}\right)^2 \Omega\, \theta_g \sum_{i=1}^{3} \sin \left(\psi + \gamma + \frac{2\pi}{3} i\right) \cos \left(\psi + \gamma + \frac{2\pi}{3} i\right) .$$

Through the trigonometric identities,

$$\sum_{i=1}^{3} \cos^2 \left(\psi + \gamma + \frac{3\pi}{2} i\right) = \sum_{i=1}^{3} \sin^2 \left(\psi + \gamma + \frac{2\pi}{3} i\right) = \frac{3}{2}$$

$$\sum_{i=1}^{3} \cos \left(\psi + \gamma + \frac{2\pi}{3} i\right) \sin \left(\psi + \gamma + \frac{2\pi}{3} i\right) = 0 . \qquad (18)$$

Equation (17) can be simplified as follows:

$$L_g = -\frac{3}{2} f_\theta \left(\frac{R_G}{R_B}\right)^2 \Omega \quad \theta_g$$

$$M_g = \frac{3}{2} \left(\frac{R_G}{R_B}\right)^2 \theta_g (k_\theta - 2I_V \Omega^2) \qquad (19)$$

In terms of the roll angle, ϕ_g, of the control gyro, one can also write

$$\theta = - \phi_g \left(\frac{R_G}{R_B}\right) \sin (\psi + \gamma) , \qquad (20)$$

which results in

$$L_g = \frac{3}{2} \left(\frac{R_G}{R_B}\right)^2 \phi_g \, (k_\theta - 2I_V \Omega^2)$$

$$M_g = \frac{3}{2} f_\theta \left(\frac{R_G}{R_B}\right)^2 \Omega \, \phi_g . \qquad (21)$$

(2) GYRO MOMENTS RESULTING FROM ELASTIC DEFORMATION OF THE BLADES

In addition to feathering motion, flapping deformation, β_0, outboard of the feathering bearing (see Reference 3 for details) of the blade and in-plane deformation of the blade, ϵ, also result in moments about the blade feathering axis which are transmitted to the control gyro. The geometrical considerations which lead to these moments are presented in Sketch 3 on Page 19. The rotor blade is shown with the elastic axis swept forward by an angle λ with respect to the feathering axis. The blade is then deformed in an in-plane direction through an angle ϵ. The moment necessary to provide this deformation is $k_\epsilon \epsilon$ where k_ϵ is the in-plane stiffness of the blade. The blade is then deformed in a flapping direction through an angle β_0. The moment necessary to produce this deformation is $k_{\beta_0} \beta_0$ where k_{β_0} is the flapping stiffness of the blade outboard of the feathering bearing. These deformations result in two orthogonal moments, $k_{\beta_0}\beta_0$ and $k_\epsilon \epsilon \sin \beta_0$, in the plane of the feathering axis. The resultant of these moments about the feathering axis is

$$M_\theta = k_{\beta_0}\beta_0 \sin(\lambda - \epsilon) + k_\epsilon \epsilon \sin\beta_0 \cos(\lambda - \epsilon) . \tag{22}$$

Using a Taylor's series expansion, $\beta_0 = \beta_0 + \bar{\beta}_0$, $\epsilon = E + \bar{\epsilon}$ where β_0, E are displacements due to static loads, and retaining only first order terms, Equation (22) becomes

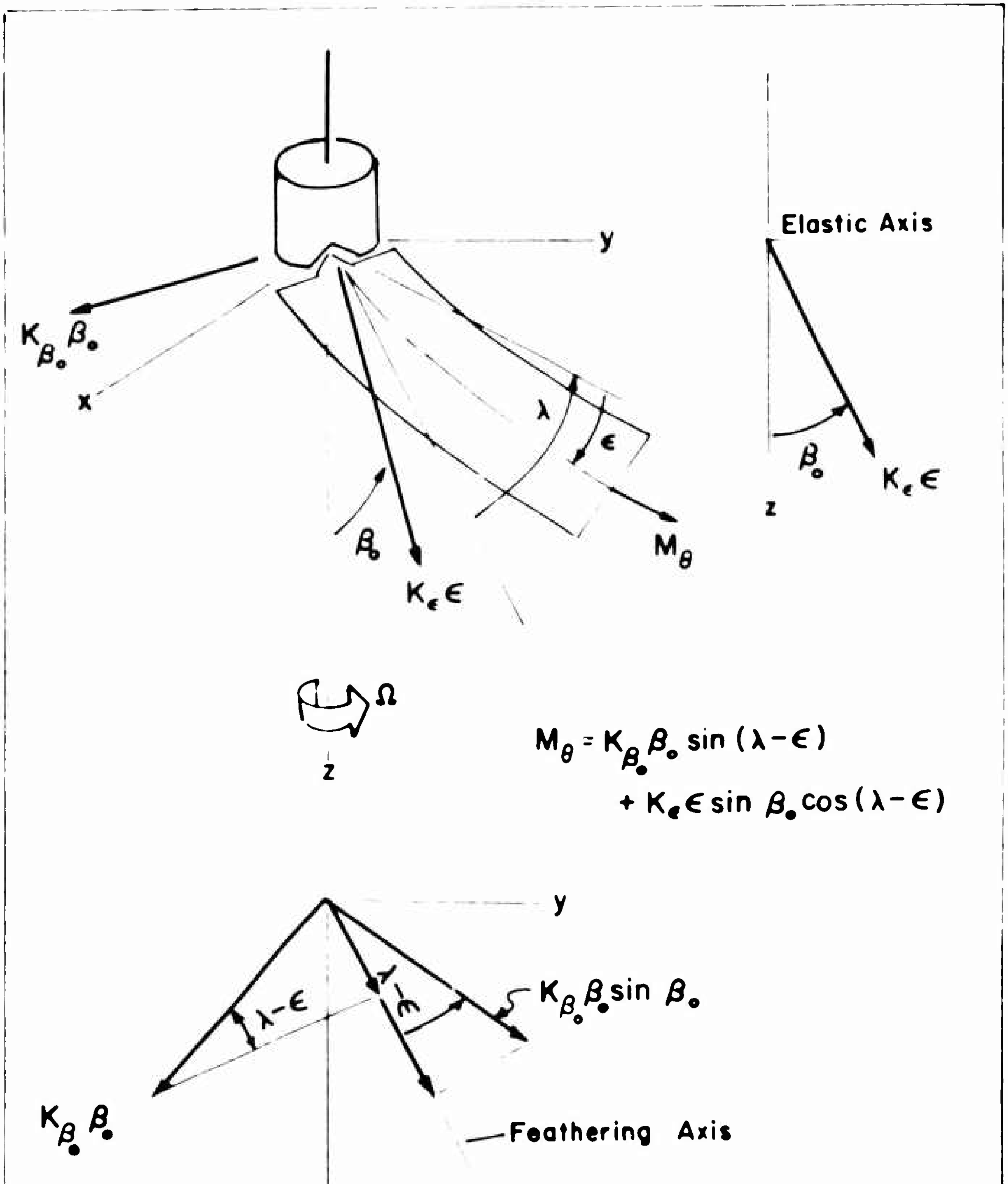
$$M_\theta(\epsilon, \beta_0) - M_\theta(E, B_0) = \left.\frac{\partial M_\theta}{\partial \beta_0}\bar{\beta}_0\right|_{B_0, E} + \left.\frac{\partial M_\theta}{\partial \epsilon}\bar{\epsilon}\right|_{B_0, E} \tag{23}$$

$$= \Big[k_{\beta_0}(\sin\lambda \cos E - \cos\lambda \sin E)$$

$$+ k_\epsilon E \cos B_0 (\cos\lambda \cos E + \sin\lambda \sin E)\Big]\bar{\beta}_0 + \Big[-k_{\beta_0} B_0 (\cos\lambda \cos E +$$

$$\sin\lambda \sin E) + k_\epsilon E \sin B_0 (\sin\lambda \cos E - \cos\lambda \sin E) + k_\epsilon \sin B_0 (\cos\lambda \cos E +$$

$$\sin\lambda \sin E)\Big]\bar{\epsilon} .$$



Elastic Axis
y
$K_{\beta_o}\beta_o$
x
λ
ϵ
β_o
$K_\epsilon \epsilon$
β_o
$K_\epsilon \epsilon$
z
M_θ
Ω
z
$M_\theta = K_{\beta_o}\beta_o \sin(\lambda-\epsilon)$
$+ K_\epsilon \epsilon \sin \beta_o \cos(\lambda-\epsilon)$
y
$\lambda-\epsilon$
$\lambda-\epsilon$
$K_{\beta_o}\beta_o \sin \beta_o$
$K_{\beta_o}\beta_o$
Feathering Axis
z

SKETCH 3

For small-angle assumption and ignoring second order terms, Equation (23) simplifies into

$$M_\theta = k_{\beta_0} \lambda \bar{\beta}_0 - E \bar{\beta}_0 (k_{\beta_0} - k_\epsilon) - B_0 \bar{\epsilon} (k_{\beta_0} - k_\epsilon) . \tag{24}$$

The first term on the right hand side of Equation (24) is the compliance correction and results from blade sweep. The second and third terms are the elastic coupling terms which disappear from elastically matched blades.

Flapping and in-plane bending deformations can be expressed in terms of rotor disc roll and longitudinal displacement of rotor blades in the rotor disc as follows:

$$\begin{aligned} \bar{\beta}_0 &= - \theta_d \cos \psi \\ \bar{\epsilon} &= r_2 \sin \psi . \end{aligned} \tag{25}$$

While, in terms of rotor disc pitch and lateral displacement of rotor blades in the rotor disc,

$$\begin{aligned} \bar{\beta}_0 &= \phi_d \sin \psi \\ \bar{\epsilon} &= - r_3 \cos \psi . \end{aligned} \tag{26}$$

So that after considerations similar to Equations (14) through (21), the total moment inputs into the control gyro inclusive of Equations (19) and (21) becomes

$$
\begin{vmatrix} L_g \\ M_g \end{vmatrix} = \frac{3}{2}\left(\frac{1}{M.A.}\right)\left\{k_{\beta_o}\lambda - E\left(k_{\beta_o} - k_\epsilon\right)\right\}\begin{bmatrix} \cos\gamma & \sin\gamma \\ -\sin\gamma & \cos\gamma \end{bmatrix}\begin{vmatrix} \phi_d \\ \theta_d \end{vmatrix}
$$

$$
+ \frac{3}{2}\left(\frac{R_G}{R_B}\right)^2 \begin{bmatrix} k_\theta - 2I_V\Omega^2, & -f_\theta\Omega \\ f_\theta\Omega, & k_\theta - 2I_V\Omega^2 \end{bmatrix}\begin{vmatrix} \phi_g \\ \theta_g \end{vmatrix} \qquad (27)
$$

$$
+ \frac{3}{2}\left(\frac{1}{M.A.}\right)\left\{B_o\left(k_{\beta_o} - k_\epsilon\right)\right\}\begin{bmatrix} \cos\gamma & \sin\gamma \\ -\sin\gamma & \cos\gamma \end{bmatrix}\begin{vmatrix} r_2 \\ r_3 \end{vmatrix}
$$

where $M.A. = \dfrac{R_B}{a}$ and $a = \dfrac{R_G}{\cos\gamma}$ (sketch 2, page 16).

The term associated with $k_{\beta_o}\lambda$ in these equations is called compliance correction. Any tilt of the rotor disc, ϕ_d and/or θ_d, relative to the mast results in moments on the control gyro which precess the gyro and results in cyclic feathering to eliminate the aerodynamic unbalance. The effect of the compliance correction, therefore, is to afford the combined rotor disc-gyro system self responsive corrections to applied external loads.

When the stiff in-plane rigid rotor system is used $(k_\epsilon > k_{\beta_o})$ there is a reduction in the effective compliance correction due to the additional term involving $(k_{\beta_o} - k_\epsilon)$. For the matched blade system $k_\epsilon = k_{\beta_o}$, which eliminates this additional term, thereby maintaining the level of compliance correction; but in addition this decouples in-plane motion inputs to the gyro control.

(B) STATIC STABILITY OF THE WIND TUNNEL MODEL

The static stability of a wind tunnel model is not the same as the stability of the full scale vehicle since the model is restrained in several degrees of freedom. While an unrestrained helicopter can be very stable in forward flight, a wind tunnel model can be unstable.

The following factors contribute to the static stability of a model:

1. Inherent stability characteristics such as compliance correction
2. Model support springs
3. Aerodynamic stabilization from a horizontal tail.

Destabilizing are:

1. Basic rotor pitch instability in absence of corrective feathering from control gyro
2. Aerodynamic drag of the rotor and hub
3. Aerodynamic moment of the fuselage

The relatively light model support springs that were used gave sufficient pitch stiffness to provide static stability even with the control gyro locked out.

The determination of the static rotor stability characteristics were preceded:

1. by selection of significant flight conditions and
2. by the calculations of the stability derivatives.

Application of the classical performance method of References 4, 5, and 6 provide load factor versus velocity data for the blade stall boundaries. These data aided in selecting collective pitch, advance ratio, and inflow ratio combinations for reference flight conditions with the retreating blade tip operating unstalled, at incipient stall, or in well-developed stall. The NASA analysis, "Aerodynamic Characteristics of Lifting Rotors", as evolved from References 7 and 8, is subsequently applied to obtain the stability derivatives.

The derivation of the control gyro equilibrium equations, showing effects of compliance correction and elastic decoupling (matching) of rotor blades, is given in Part A of this section. These results show that a free-feathering gyro control can affect the rotor disc contribution to the static stability of the helicopter. It should be noted that a rigid rotor without free-feathering capability and compliance correction or automatic control will provide a large destabilizing contribution to the longitudinal stability of the helicopter. The remaining contributions to static longitudinal stability will result from rotor thrust variation with angle of attack (with the c.g. aft of the thrust axis), rotor drag variation with angle of attack (with the rotor above the c.g.), moment contributions of the fuselage, horizontal tail forces producing body pitching moments, and reaction forces from the support system in the case of our model (see page 45).

The analysis made on a simple five-degree-of-freedom description for the gyro-free case showed that the model was statically stable for the configuration analyzed. These solutions, carried only to 100 miles per hour, are not presented since more significant results can be obtained directly from the test data.

The test results show that all configurations tested in the full-scale tunnel tests with the control gyro locked or free were statically stable. Since the spring rate of the model support was known to be 464 in-lbs/degree, a measure of the static stability of these configurations has been obtained.

Transonic dynamics tunnel tests were made with the gyro control free with the same support spring rate of 464 in-lbs/degree for Configurations A through L. Model support springs were changed for Configuration M to larger values as shown in Figure 13, page 45, to reduce observed response amplitudes of the model. While testing Configuration M at a simulated speed of 240 miles per hour, the electromechanical actuator used to position the model pitching attitude parted, thus leaving the model completely free in pitch (see page 65). The model began to pitch nose up very slowly, which subsequently led to failure of the model support. This test result shows that this configuration was slightly statically unstable at this speed in the absence of some pitch stiffness from the model support.

In summary, the static stability of the test configurations was not a serious problem area. It is possible to mechanically support the model with limit stops which unload the rotor when contacted. Such a support was utilized in the TDT tests; however, warning lights indicated that the stops had not contacted during the test runs.

Further examination of equation (27) shows that the feathering bearing friction term permits an equilibrium position for the control gyro with an aerodynamic unbalance on the rotor disc. The magnitude of this unstable contribution will be determined by the relative magnitudes of the compliance correction and the feathering bearing friction.

The large magnitude of the oscillating pitch link load (which is primarily a steady gyro trim moment in the non-rotating part of the control system), which is summarized in Figures 32 and 33, was not anticipated. Examination of the oscillograph records showed a phase difference of about 90° ($\pm 10^{\circ}$) between the point of maximum link load and the point of maximum feathering angle amplitude. This phasing indicated that the load was principally a feathering friction or aerodynamic damping-in-feathering type of load. Further examination of the records showed that most of the torque measured at the pitch link was also present in the blade torsion measurement at radial station 22 and, therefore, must be generated in the outboard portion of the blade.

Aerodynamic damping due to feathering velocity is by theory given by the following expression

$$M_{\dot{\theta}}^{\dot{\theta}} = \frac{3}{2} q_r c^3 \left[\frac{1}{2} \left(C_{m_q} + C_{n_{\dot{\alpha}}} \right) + \frac{1}{3} \left(C_{L_{\dot{\alpha}}} + C_{L_q} \right) \frac{R\lambda}{c} - \frac{C_{L_\alpha}}{4} \left(\frac{R\lambda}{c} \right)^2 \right]. \quad (28)$$

The effective λ's obtained with the rotor rotating were used in the above expression for several configurations to calculate the theoretical aerodynamic feathering damping moment for comparison with test results. This comparison is shown on Figure 6, Page 25 of this report.

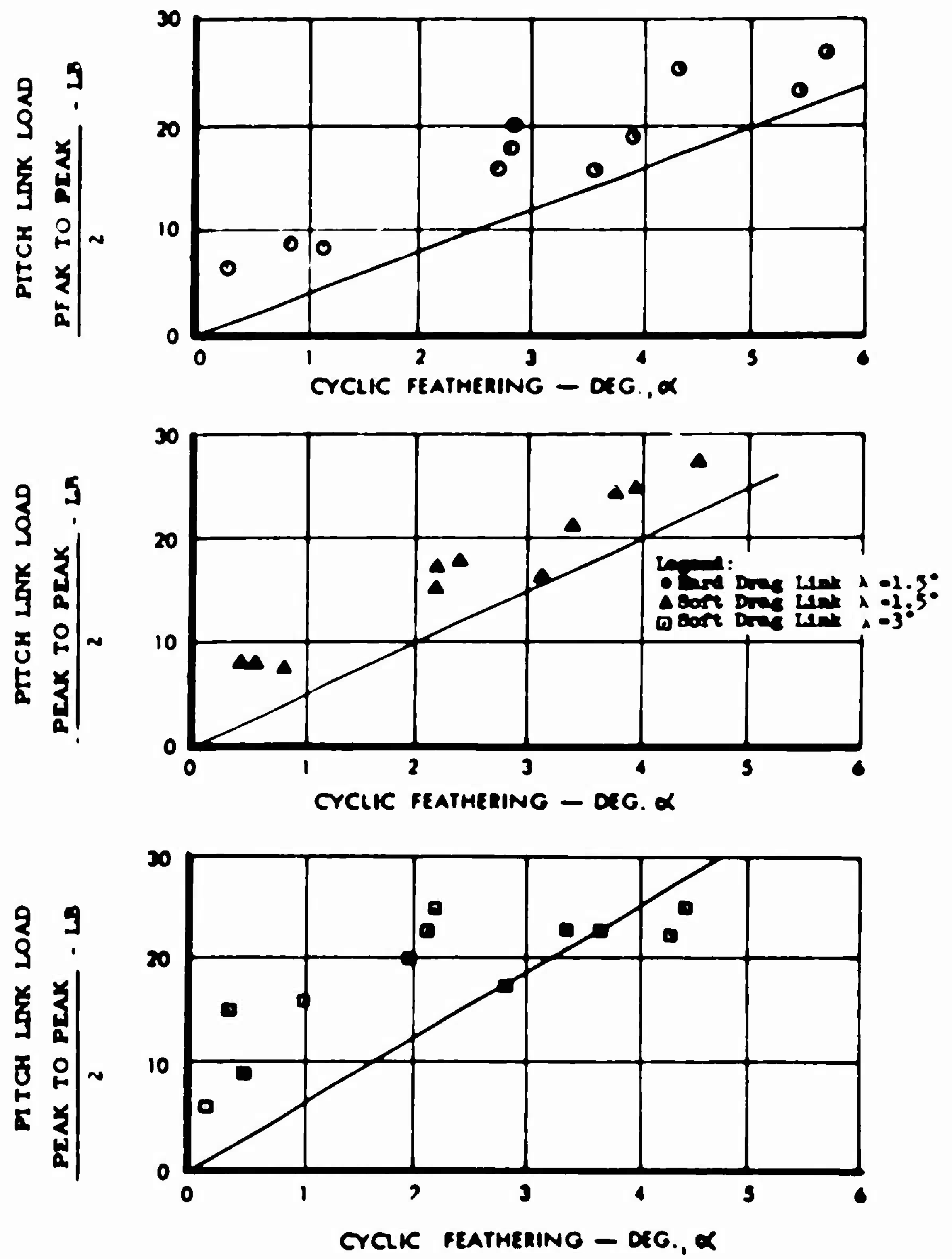


FIGURE 6 MEASURED PITCH LINK LOADS COMPARED WITH THEORETICAL AERODYNAMIC FEATHERING DAMPING MOMENTS (M)

(C) DYNAMIC STABILITY ANALYSIS, HOVERING

In part A of this section, the equilibrium equations for the control gyro were derived. For the more complete description of the helicopter stability, the equilibrium equations for the fuselage, rotor disc, motions in the rotor disc, as well as the control gyro have to be considered. For this purpose, a 14-degree-of-freedom stability system was programmed on the IBM 7090 (Reference 2). If it is assumed that the fuselage is rigid with its c.g. located at the rotor center line, the stability system can be broken down into a 4-degree-of-freedom collective set and a 10-degree-of-freedom cyclic set of stability equations. This assumption of an uncoupled collective - cyclic system was made when investigating the dynamic stability in hovering of these model rotors. The collective set of equations includes effects of vertical translation of the fuselage, collective first elastic flapwise bending (i.e., all blades move up or down simultaneously), collective first elastic in-plane berding, and vertical translation of the control gyro. The cyclic set of equations includes effects of longitudinal and lateral translations of the fuselage, pitch and roll of the same, pitch and roll of the control gyro, pitch and roll of the rotor disc (i.e., cyclic first elastic flapwise bending), and longitudinal and lateral displacements of the blades in the rotor disc (i.e., cyclic first elastic in-plane bending). The coordinates and basic equations in matrix form of the 14-degree-of-freedom hovering stability program of Reference 2 are reported on pages 28 - 31.

The collective set of equations seldom causes instability since, in general, the stiffness in the collective feathering degree of freedom (i.e., translation of the gyro) is very large, hence, preventing it from coupling with fuselage translation. Therefore, only the cyclic stability problem has been investigated herein.

The IBM program considers effects of large deflection on the mechanical terms, whereas the aerodynamic inputs are based on small angle strip-theory assumptions in hovering. The parametric variations include hub stiffness, drag link stiffness, control gyro mass moment of inertia, control gyro damping, blade sweep, load factor, and rotor RPM. Since the model in air or freon is scaled to the same full-scale vehicle, no distinction has to be made in the analysis for different test media. Furthermore, since only the first mode flapwise and in-plane bendings are considered, the effect of blade twist has not been investigated (i.e., twist merely means a change of collective pitch to match the selected load factor).

The basic data used in the analysis are presented in Reference 3. For convenience, the results of the analysis with comments are summarized in Table 2. As can be seen from it, the test configurations are stable for the entire test program except for the very low to marginally damped in-plane bending modes, which essentially are due to the exclusion of the structural damping involved in the in-plane bending modes and the undamped body roll response mode in the hard hub, hard drag link, and low gyro inertia configuration. The latter configuration was not tested.

The inertial - structural elements of the equations of motion of the rotor and swashplate combination with the control input of the swashplate rigidly attached to the rigid body coordinates of the combined configuration.

Two independent sets of elements in terms of generalized non-rotating coordinates of which the generalized displacements are:

A. The Cyclic Set

X_r, Y_r $\equiv$ Cartesian components, perpendicular to the rotor shaft, of the translational displacement of the rotor hub.

ϕ_c, θ_c $\equiv$ Cartesian components of the angular displacement (roll, pitch) of the combined configuration—rotor, swashplate, and interconnecting shaft and linkage.

ϕ_g, θ_g $\equiv$ Cartesian components of the relative angular displacement (roll, pitch) of the swashplate.

$\mathfrak{q}_2$, $\mathfrak{q}_3$ (nr) $\equiv$ Cyclic cartesian components depicting fundamental blade flapping displacements.

r_2, r_3 (nr) $\equiv$ Cyclic cartesian components depicting fundamental blade in-plane bending displacements.

B. The Collective Set

$\mathfrak{z}_r$ $\equiv$ The vertical component - i.e., in the direction of the rotor shaft - of the translational displacement of the rotor hub.

$\mathfrak{z}_g$ $\equiv$ The relative vertical displacement of the swashplate.

$\mathfrak{q}_1$ $\equiv$ Collective component depicting fundamental blade flapping displacements.

r_1 $\equiv$ Collective component depicting fundamental blade in-plane bending displacements.

The relative physical displacements - i.e., feathering, flapping, and in-plane bending angular displacements - of the individual blades are:

$$(\theta_j) = -\left(\frac{\cos\alpha_3}{\epsilon_2^{\bullet}}\right)(z_g) + \left(\frac{R_c\cos\alpha_3}{\epsilon_2^{\bullet}}\right)\{\sin\gamma, \cos\gamma\}\begin{bmatrix}\cos a_j, & -\sin a_j \\ \sin a_j, & \cos a_j\end{bmatrix}\begin{bmatrix}\cos\psi_s, & \sin\psi_s \\ -\sin\psi_s, & \cos\psi_s\end{bmatrix}\begin{vmatrix}\phi_g \\ \theta_g\end{vmatrix}$$

$$(\beta_j) = (q_1) + \{\sin a_j, \cos a_j\}\begin{bmatrix}\cos\psi_s, & \sin\psi_s \\ -\sin\psi_s, & \cos\psi_s\end{bmatrix}\begin{vmatrix}q_2 \\ q_3\end{vmatrix}_{(nr)}$$

$$(\epsilon_j) = (r_1) + \{\sin a_j, \cos a_j\}\begin{bmatrix}\cos\psi_s, & \sin\psi_s \\ -\sin\psi_s, & \cos\psi_s\end{bmatrix}\begin{vmatrix}r_2 \\ r_3\end{vmatrix}_{(nr)}$$

where

$j = 1, 2, 3$

$\dfrac{R_c \cos\alpha_3}{\epsilon_2^{\bullet}}$ = θ_j due to a unit angular displacement of the swashplate about an axis perpendicular to the direction of the jth attach point on the swashplate

$-\dfrac{\cos\alpha_3}{\epsilon_2^{\bullet}}$ = θ_j due to a unit vertical displacement of the swashplate.

$\psi_s = -\Omega t$ = const.

$a_1 = 0, a_2 = \frac{2\pi}{3}, a_3 = \frac{4\pi}{3}$.

The Equation of Motion

(In the following equations, terms of the differential equation are related to the basic properties of the rotor system by a systematic sequence of abbreviations)

A. The Cyclic Set (1 Generalized Displacements)

$$\left[M\right]_A \left\{\begin{array}{c} \begin{vmatrix} x_r'' \\ y_r'' \end{vmatrix} \\ \begin{vmatrix} \phi_c'' \\ \theta_c'' \end{vmatrix} \\ \begin{vmatrix} \hat{\phi}_\gamma'' \\ \hat{\theta}_\gamma'' \end{vmatrix} \\ \begin{vmatrix} q_2'' \\ q_3'' \end{vmatrix}_{(nr)} \\ \begin{vmatrix} r_2'' \\ r_3'' \end{vmatrix}_{(nr)} \end{array}\right\} + \left[C\right]_A \left\{\begin{array}{c} \begin{vmatrix} x_r' \\ y_r' \end{vmatrix} \\ \begin{vmatrix} \phi_c' \\ \theta_c' \end{vmatrix} \\ \begin{vmatrix} \hat{\phi}_\gamma' \\ \hat{\theta}_\gamma' \end{vmatrix} \\ \begin{vmatrix} q_2' \\ q_3' \end{vmatrix}_{(nr)} \\ \begin{vmatrix} r_2' \\ r_3' \end{vmatrix}_{(nr)} \end{array}\right\} + \left[K\right]_A \left\{\begin{array}{c} \begin{vmatrix} x_r \\ y_r \end{vmatrix} \\ \begin{vmatrix} \phi_c \\ \theta_c \end{vmatrix} \\ \begin{vmatrix} \hat{\phi}_\gamma \\ \hat{\theta}_\gamma \end{vmatrix} \\ \begin{vmatrix} q_2 \\ q_3 \end{vmatrix}_{(nr)} \\ \begin{vmatrix} r_2 \\ r_3 \end{vmatrix}_{(nr)} \end{array}\right\} = \left|Q\right|_A .$$

B. The Collective Set (4 Generalized Displacements)

$$\left[M\right]_B \begin{vmatrix} z_r'' \\ \hat{z}_\gamma'' \\ q_1'' \\ r_1'' \end{vmatrix} + \left[C\right]_B \begin{vmatrix} z_r' \\ \hat{z}_\gamma' \\ q_1' \\ r_1' \end{vmatrix} + \left[K\right]_B \begin{vmatrix} z_r \\ \hat{z}_\gamma \\ q_1 \\ r_1 \end{vmatrix} = \left|Q\right|_B$$

where

$$(\;)' = \frac{d}{d\psi_s}(\;) , \qquad (\;)'' = \frac{d^2}{d\psi_s^2}(\;) , \qquad \psi_s = -\Omega t$$

$$\hat{\phi}_\gamma = \left(\frac{R_\gamma \cos\alpha_3}{\epsilon_L^\circ}\right)\phi_\gamma , \quad \hat{\theta}_\gamma = \left(\frac{R_\gamma \cos\alpha_3}{\epsilon_L^\circ}\right)\theta_\gamma , \quad \hat{z}_\gamma = \left(\frac{\cos\alpha_3}{\epsilon_L^\circ}\right) z_\gamma .$$

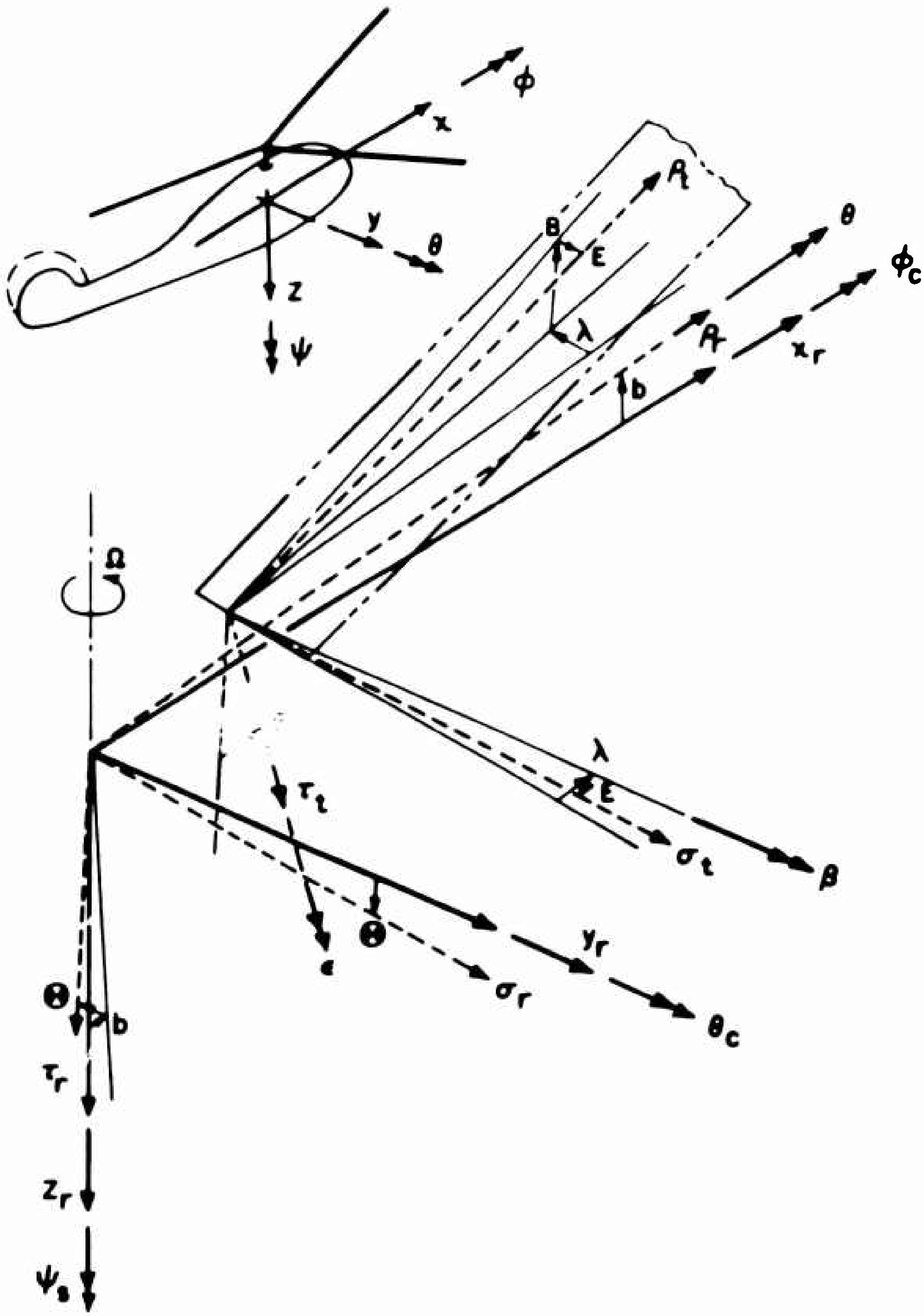


Figure 7 Definition of Non-Rotating Coordinate System

Table 1. Summary of Predicted Cyclic Hovering Stability C
for the Untwisted Metal Blade Air Tunnel Configu

Hub Stiffness	Drag Link Stiffness	Blade Sweep (Deg)	Control Gyro Inertia (Slug-Ft^2)	Control Gyro Damping (Ft-Lbs-Sec)	Load Factor	Rotor RPM
Hard	Hard	1.5	0.050	1.160	Change	1055
Hard	Hard	1.5	0.005	1.160	Change	1055
Hard	Soft	1.5	0.0125	1.160	Change	1055
Hard	So[illegible]	1.5	0.005	1.160	Change	1055
Soft	S[illegible]	1.5	0.0125	1.160	Change	1055
Soft	Soft	6.58	0.0125	1.160	Change	1055
Hard	Soft	1.5	Change	1.160	1.0	[illegible]
Hard	Soft	Change	0.0125	1.160	1.0	1055
Hard	Soft	1.5	0.0125	Change	1.0	1055
Hard	Soft	1.5	0.0125	1.160	1.0	Change
Hard	Soft	1.5	0.0125	1.160	Change	Change
Hard	Soft	1.5	0.0125	1.160	Change	Change

* Spring rate of body support system was included in the analysis.

...aracteristics of the Rotor Fuselage Free Body Combination *

...ation

Remarks
With the exception of marginally stable 0.28/rev and 2.37/rev inplane bending modes, the configuration is **stable**.
Body roll response mode is becoming unstable at high load factors. Both high and low inplane bending modes are unstable. This configuration is not tested.
The configuration is stable.
The configuration is stable.
Slightly unstable 0.06/rev body pitch and 0.2[illegible]/rev inplane bending modes.
A change in blade sweep to 6.58° stabilizes the body pitch modes but leaves the inplane bending mode slightly unstable.
The configuration is stable for either control gyro inertia, 0.005 or 0.200 slugs-ft^2.
The configuration is stable for both 3° and 6° blade sweep. Larger blade sweep makes the body mode stable.
Zero damping configuration has a slightly unstable 1.85/rev inplane bending mode. 3 x nominal damping also makes the 0.17/rev body pitch mode slightly unstable.
Analysis from 620 RPM to 1320 RPM shows no instability.

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V. DESCRIPTION OF TEST ARTICLE

A. MODEL DESCRIPTION

The model as shown in Figures 3 and 4 has a single 10-foot-diameter main rotor, no tail rotor, and a body shaped and sized to represent a one-third scale model of a 3000- to 4000-pound class helicopter.

The skeleton or inertia frame of the model is a very stiff welded structure of 1/4-inch steel plate. This frame is attached to an internal base plate structure through a system of springs such that the model has five degrees of freedom with respect to the base. The spring rates and travels given in Reference 3 are nominal values and can be varied by changing the springs and stops in the model. A pneumatic "caging" cylinder mounted between the model frame and the base plate permits the model operator to lock the model to the base in an emergency. Rotor torque reaction is transmitted from the model to the base by a couple consisting of a lateral force through the lateral springs near the model c.g. and an opposite lateral force near the end of the tail boom which is reacted by a long arm inside the body that attaches to the base plate. A schematic of this system is shown in Figure 13.

The rotor is driven through a two-stage transmission system by three variable-frequency, water-cooled, 38-horsepower synchronous electric motors. The motors drive a common large sprocket wheel through individual timing belts for a 3:1 speed reduction. An 11-tooth chain drive sprocket on the lower end of the jack shaft drives, through a roller chain, a large sprocket on the lower end of the rotor shaft. By changing this large sprocket, reductions of 5.46:1 or 2.73:1 can be achieved in the chain drive stage. The model drive system is designed for 60 continuous horsepower maximum.

The mass c.g. locations and pitch and roll moments of inertia of the model can be varied by attaching as much as 250 pounds of ballast to pads provided on the inertia frame.

The pitching attitude of the base plate inside the model(and thus the pitching attitude of the model) can be varied by the model operator through the use of an electromechanical actuation in the model from about 18° nose down to about 8° nose up.

The swashplate and integral gyro are mounted on the rotor shaft immediately below the rotor. An electromechanical actuator is provided to control collective pitch, and two low-pressure air cylinders are installed to allow the model operator to apply pitch and roll trim forces to the gyro by modulating the pressure in the cylinders with pressure regulators mounted on the console. A switch on the model operator's console connected to a solenoid friction brake allows the operator to lock the gyro position. A fiberglass and sheet aluminum body shell covers the model and includes a fixed horizontal tail surface of 20 inches span and 7.55 inches chord positioned to neutralize the body pitching moments. The body shell is attached to the inertia frame.

The rotors tested were all three-blade, 7.55-inch constant chord, 10-foot diameter, with NASA 0012 airfoil sections. The hub used for all tests was of the Lockheed "rigid" or cantilever bending type with no flap and lag hinges. The feathering bearings were the "caged" roller type. The hub and gyro are shown in Figures 10 and 12. The hub is a single piece of steel having a thin, flat center section branching out into three cylindrical spindles. The thin section serves to concentrate flapping deflections inboard of the feathering bearings in an area close to the pitch link attachment, so that blade flapping does not couple with blade feathering. Section IV of this report includes a derivation of the relationships between blade flap bending outboard of the feathering bearings and blade feathering moment, which will further clarify this statement. Flapping stiffness in this area can be increased by sandwiching the flat hub center section between two plates which act as cantilever springs. A fork fitting with a vertical pivot bolt transmits flap bending from the blade into the feathering bearing housing while permitting lag motion. This lag motion is restrained by a "C" shaped drag link. In the course of the program, four sets of drag links were built with different stiffnesses. Thus blade first mode chord stiffness could be varied by changing these drag links. The two sets of drag links which were used in the wind tunnel test program resulted in in-plane bending frequencies of .7p and 1.2p at rotor design RPM . as shown in Figures 14 and 15. Blade centrifugal loads bypass the feathering bearing housing and are carried by a multistrap, tension-torsion bundle attached inside the blade and to the outboard ends of the hub spindles.

Two different types of blade construction were used. Typical cross sections are shown in Figures 8 and 9. The fiberglass blade was an attempt to achieve elastic and chordwise EI matching all along the blade. To achieve this, a steel "I" beam spar was designed to provide approximately 90 per cent of the desired flap stiffness. This spar was slipped into (but not fastened to) a molded fiberglass "D" spar which composed the leading 30 per cent of the blade and provided the remaining 10 per cent of the flap stiffness and almost all of the chord stiffness. Blade leading edge ballast was installed in the form of lead shot molded in epoxy to the fiberglass. The trailing edge 70 per cent consisted of polyurethane foam covered with fiberglass. The fiberglass blades were built only in the untwisted configuration and were tested only in air in the speed range up to 106 miles per hour.

The aluminum blades were built with the same construction in zero twist and -8° twist configurations. The aluminum blades had essentially the same flapping stiffness as the fiberglass blades. However, the chord stiffness of the aluminum blades was very high, and they could be "matched" to their flap stiffness only in the first mode by use of very soft drag links. The leading edge ballast was removable and was changed to achieve the proper scaling of blade mass and feathering inertia when the blades were converted from the air test configuration to the freon test configuration. Tungsten wire was used as ballast in the form of a trapped (but not bonded) bundle fastened only at the blade root in order to achieve the proper blade mass ratio and c.g. location without affecting the chord or flap stiffnesses of the blade structure. The insertion of tungsten ballast at the trailing edge was necessary to achieve sufficient feathering inertia for the freon test case.

B. MODEL PROPERTIES AND SIMULATION

The physical properties of the model and rotors are given in Table 1. This type of generalized model testing can be scaled to any size that is of interest. However, the particular, simulated full-scale vehicle that was used as a scaling and design reference in order to insure that the model design represented a realistic configuration is shown with the applicable scale factors in Table 1. The drag link stiffnesses, blade EI, mass distribution, geometry, and other pertinent basic data for the configurations tested are given in Reference 3.

It was desired to simulate the full-scale aerodynamic and dynamic situation of a helicopter rotor as closely as possible. To scale the aerodynamic effects, it was considered necessary to match Reynolds number, Mach number, dynamic pressures, geometry, and angles. This means that the aerodynamic coefficients are matched. Velocity scaling is thus introduced in going from air to freon as the test medium. Since aerodynamic forces are the product of aerodynamic coefficients, dynamic pressure, and model areas, these forces vary only with the areas or the geometric scale factor squared.

To maintain dynamic similitude, it was necessary to hold the ratio of inertial forces to aerodynamic forces. An excellent example of this relationship can be observed in the coning angle which is the ratio of the aerodynamic blade lift force to the blade centrifugal force, when neglecting structural stiffness. The centrifugal "stiffness" forces and the structural stiffness levels must therefore be in the same ratio as full-scale levels to insure dynamic similitude. Blade lift is a function of fluid density and rotational speed squared, and centrifugal force is a function of blade mass and rotational speed squared. Thus masses must change by the same ratio as do the fluid densities of the test medium. In other words, kinetic energy ratios between dynamic and aerodynamic phenomena are held constant. This also means that the ratios of blade operating frequencies to natural frequencies are maintained providing the elastic properties of the blades are not changed in the process of changing the mass.

If the simulated vehicle is compared with the model in freon, it can be shown that the full-scale effects of Mach number and Reynolds number have been exactly matched. Further, the Strouhal number is matched, which, restated, means that the reduced frequency is matched and therefore the full-scale dynamic effects are represented. These properties combined in one model, including forward flight, are probably unique in helicopter technology.

Froude number, however, is not matched by the present scaling. This parameter may be interpreted in this case as a ratio of vehicle kinetic energy to potential energy. Therefore, model height loss to speed gained is not scaled to the full-scale vehicle. This has an effect on the low-frequency stability of a vehicle in free flight. However, the spring rate and limited travel of the support system impose added restrictions on the investigation of this area; therefore, model results in this particular area are of limited use.

TABLE 2 MODEL PROPERTIES AND SIMULATION

	Simulated Vehicle	Model in Air	Scale Factor in Air	Model in Freon	Scale Factor in Freon
Number of blades	3	3	1	3	1
Blade Chord (ft)	1.867	.629	.337	.629	.337
Rotor Diameter (ft)	29.7	10	.337	10	.337
Solidity	.12	.12	1	.12	1
Pitch Inertia (slug-ft^2)	1990	11.5	.00579	38.9	.0195
Roll Inertia (slug-ft^2)	326	2.1	.00644	6.4	.0195
Mass (lb)	3000	286	.0954(1)	518	.1726
Rotor Lift (lb)	3000	314	.105	314	.105
Disc Loading (lb/ft^2)	4.33	4.00	.925	400	.925
Altitude/Temperature	6000ft/95°F	Std.Day	-	110°F	-
Density (slugs/ft^3)	.001783	.002378	1.334	.0080	4.49
Speed of Sound (ft/sec)	1158	1118	.966	525	.453
Velocity (ft/sec)	-	-	.832	-	.453
Tip Speed (ft/sec)	666	554	.832	302	.453
Rotor RPM	428	1055	2.47	576	1.348
Force	-	-	.105	-	.105
Moment	-	-	.0353	-	.0353
Acceleration	-	-	2.055	-	.61

(1) When tested in air, the pitch and roll inertias are simulated, but there is a discrepancy in model weight simulation. Therefore, full scale acceleration = $\frac{1}{2.055} \times \frac{286}{155}$ x measured accelerations.

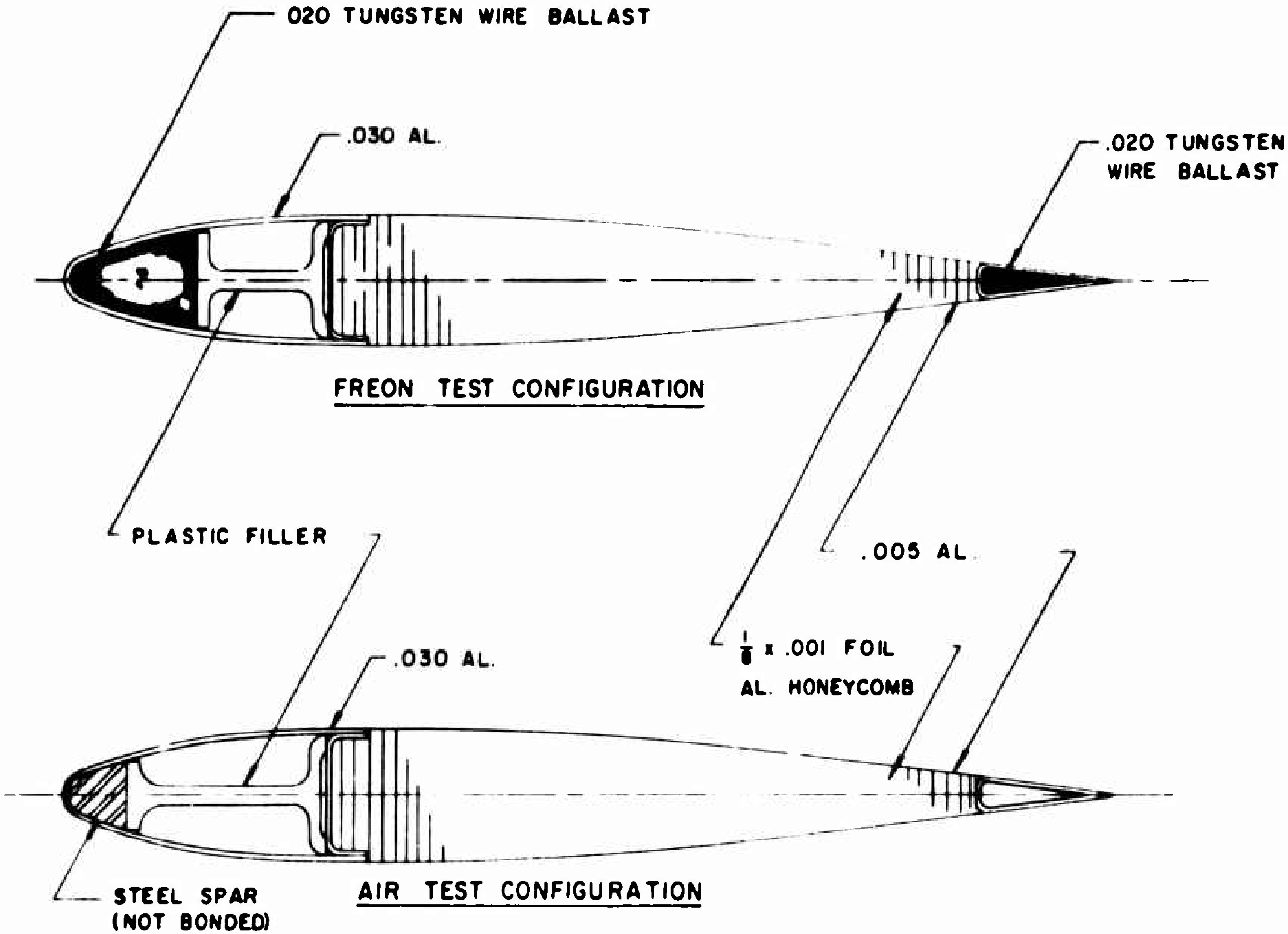

FIGURE 8 ALUMINUM BLADE CROSS SECTIONS

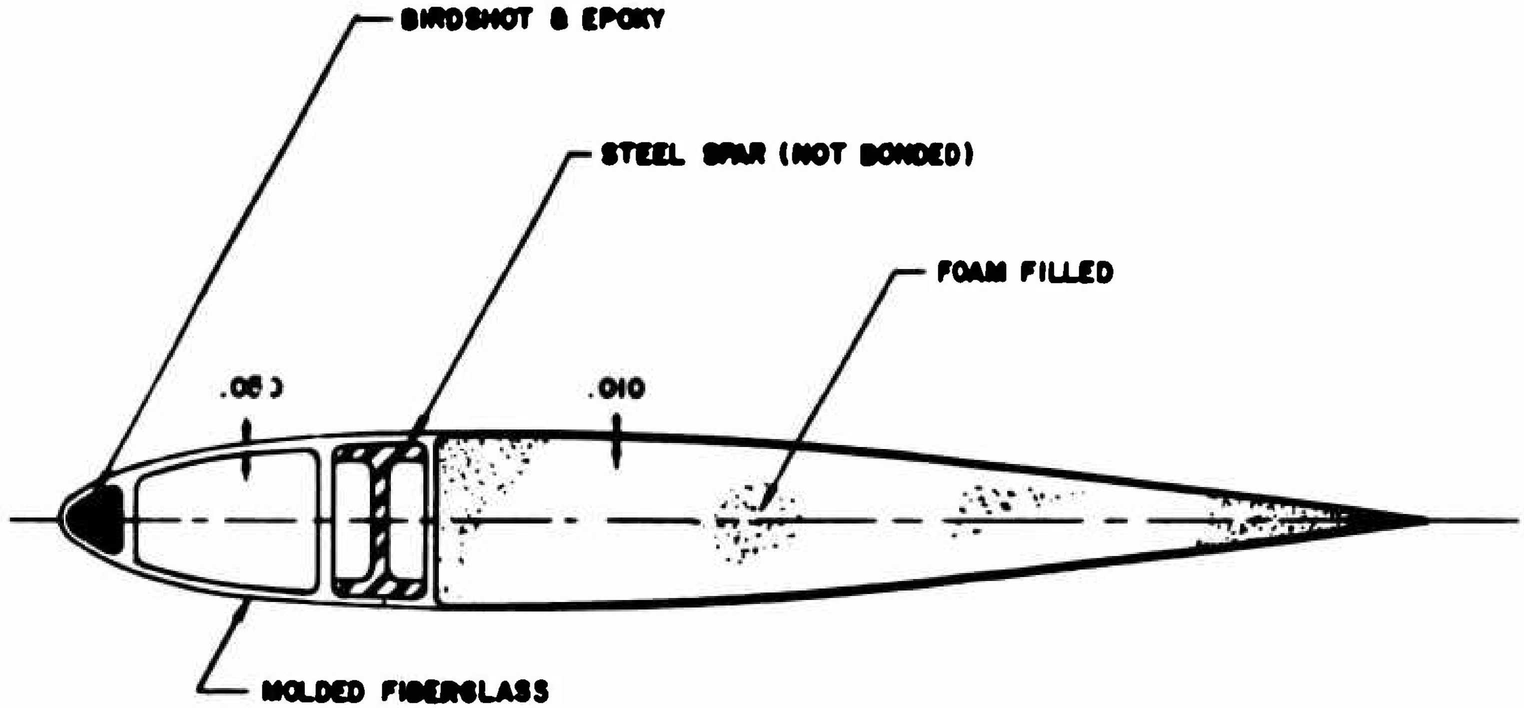

FIGURE 9 FIBERGLASS BLADE CROSS SECTION

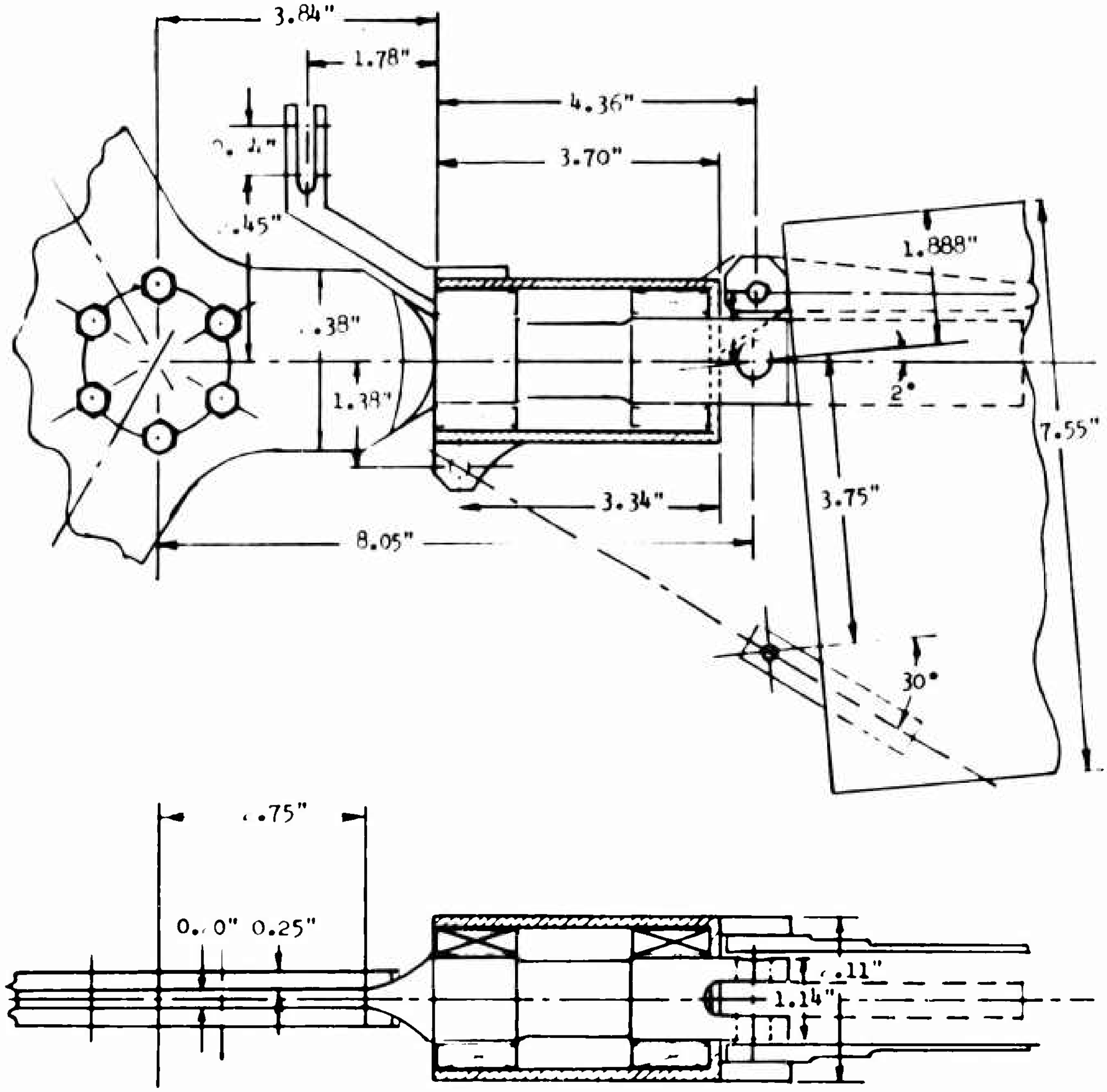

FIGURE 10 GEOMETRY OF THE HUB-SPINDLE ASSEMBLY

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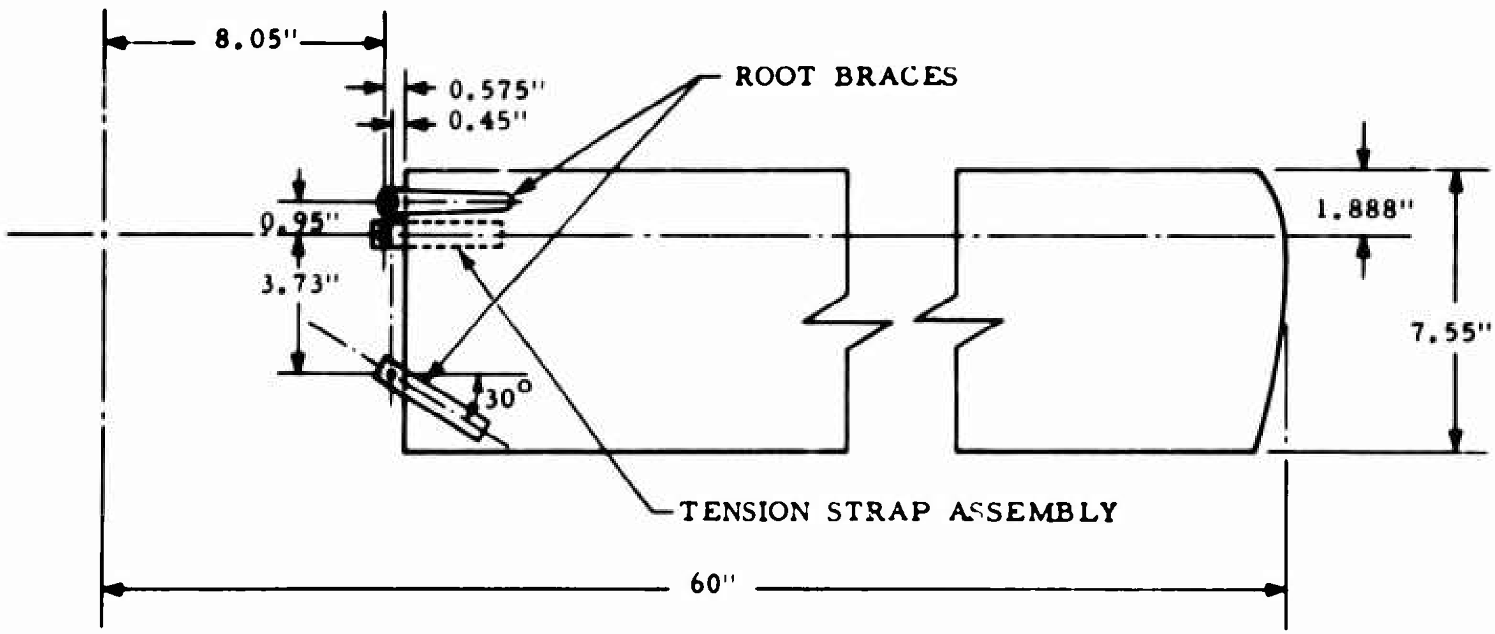

FIGURE 11 BLADE AND BLADE ATTACHMENT GEOMETRY

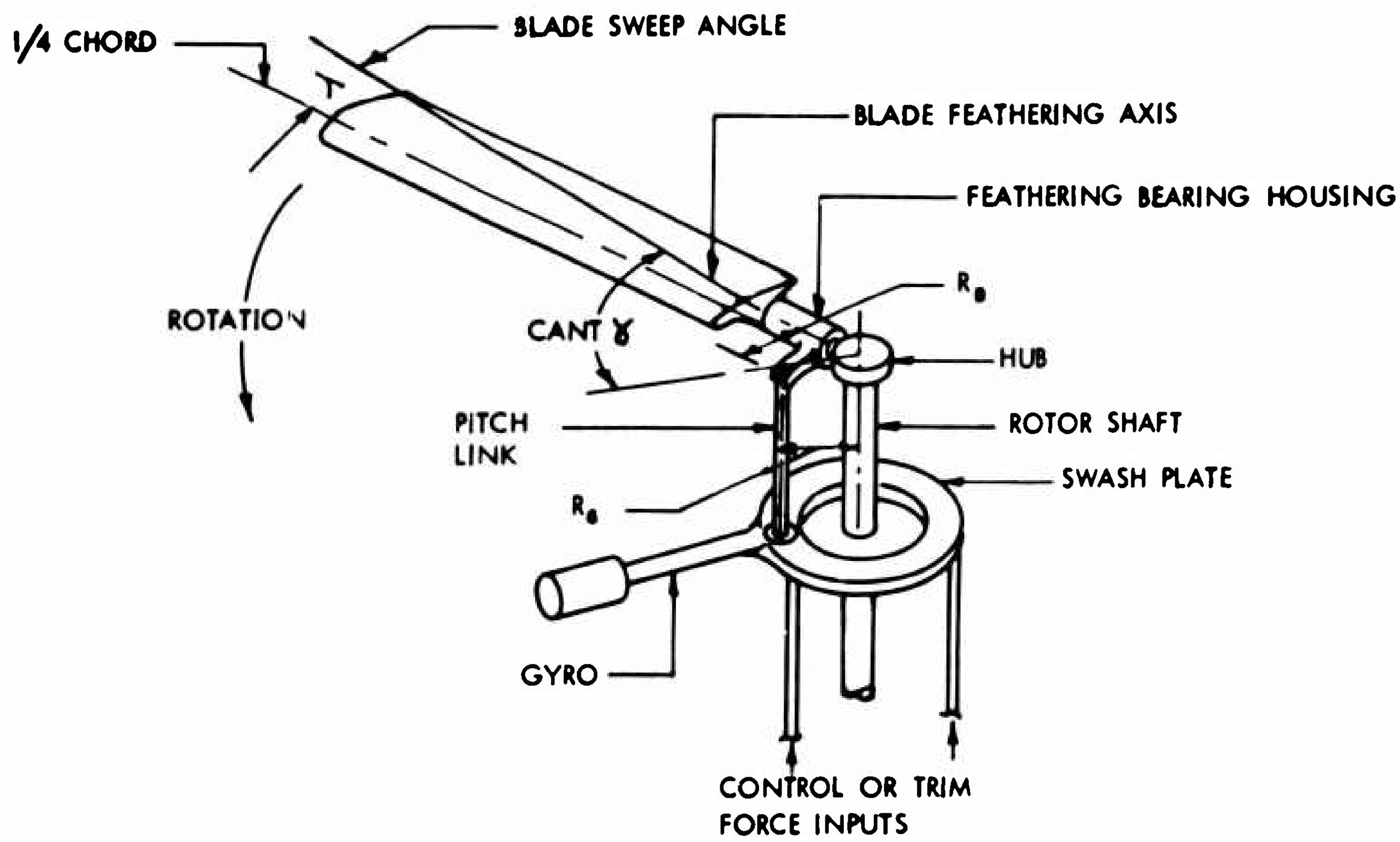

FIGURE 12 CONTROL SYSTEM SCHEMATIC

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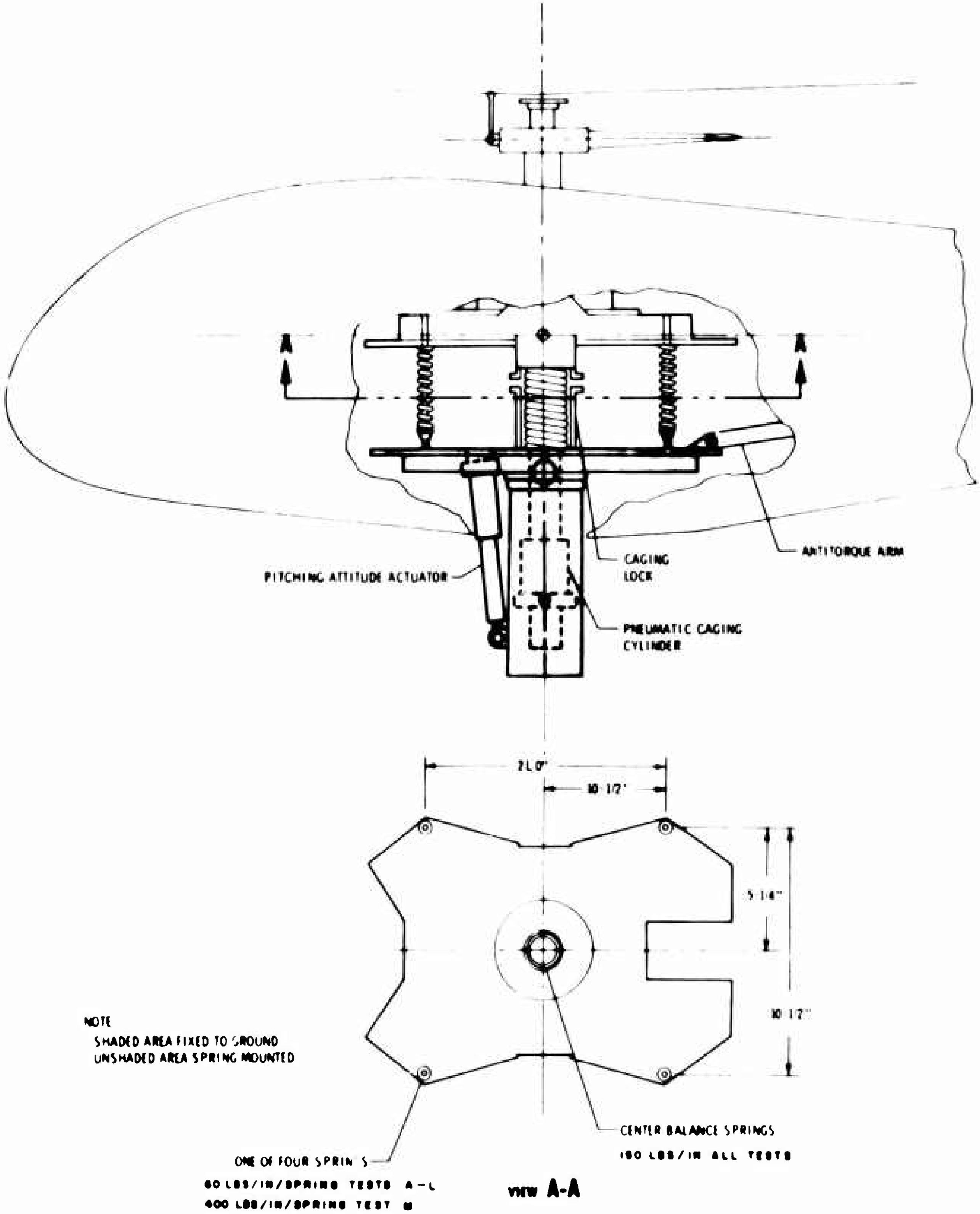

FIGURE 13 MODEL SUPPORT SYSTEM SCHEMATIC

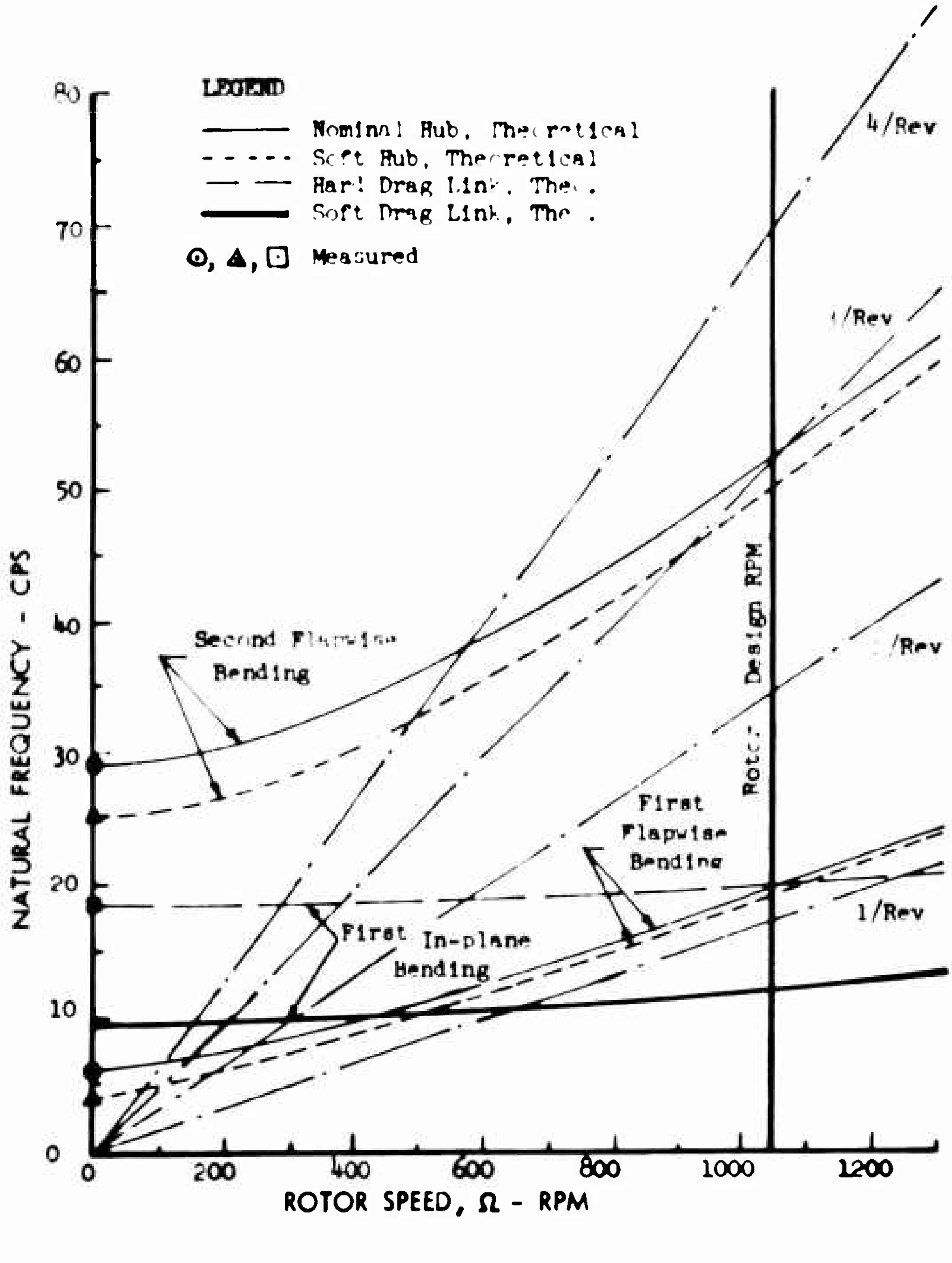

FIGURE 14 UNCOUPLED NATURAL FREQUENCIES OF BLADES VS ROTOR SPEED FOR AIR TUNNEL CONFIGURATION WITH MEASURED FREQUENCIES AT Ω = 0

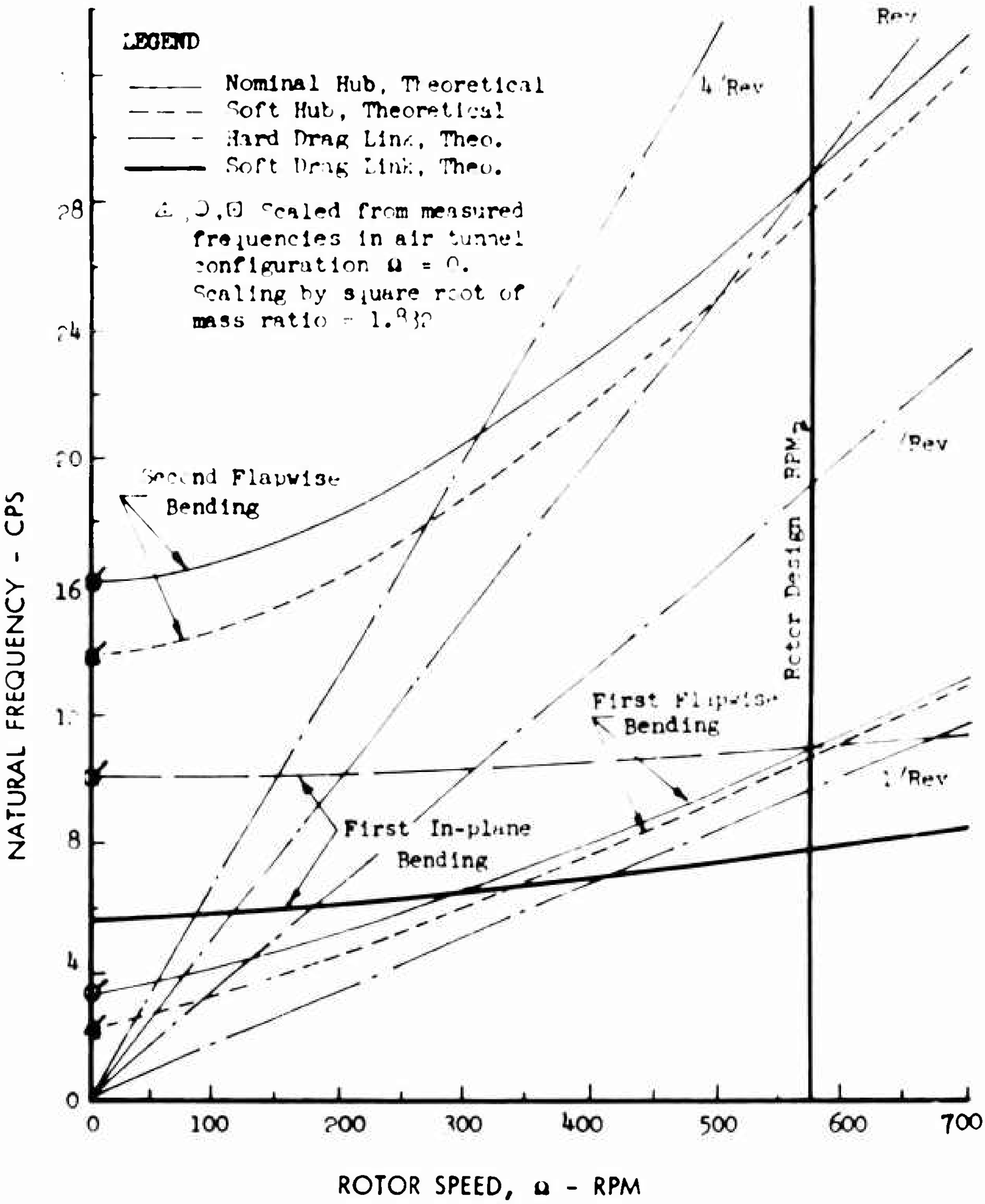

FIGURE 15 UNCOUPLED NATURAL FREQUENCIES OF BLADES VS ROTOR SPEED FOR FREON CONFIGURATION, SCALED FROM AIR TUNNEL CONFIGURATION

C. <u>INSTRUMENTATION</u>

The instrumentation used in this program falls into two basic categories.

1. Model situation display instrumentation was necessary so that the model operators could monitor and set up the desired test conditions. In each tunnel, the flow conditions such as "q", density, and temperature were taken from tunnel instrumentation. Rotor RPM was displayed on an electronic pulse counter fed by a stationary magnetic pickup set close to a rotating multitooth gear on the model drive jack shaft. The number of teeth on the gear was made such that 60 pulses were generated per rotor revolution, and thus the counter read directly in RPM. Model motor temperatures were taken from thermocouples built into the motors and printed out continuously on a Brown temperature recorder. Current, voltage, and cycles-per-second meters and the necessary controls for the current fed to the model motors were contained in a model operator's console which was part of the NASA-supplied variable-frequency power source.

   The following model forces and positions were displayed on standard 2.75-inch aircraft autosyn indicators on the model operator's console (Figure 21):

   a. Rotor thrust - force parallel to the rotor shaft.

   b. Model drag - aft force perpendicular to the rotor shaft.

   c. Model pitch attitude - angle of the internal base plate in the model with the tunnel horizontal center line. This is <u>not</u> the same as shaft angle to the vertical, as it is measured below the soft spring system in the model which allows limited pitching with respect to the base plate.

   d. Model collective pitch angle

   e. Model rolling moment

   f. Model pitching moment

   g. Gyro roll angle with respect to the rotor shaft

   h. Gyro pitch angle with respect to the rotor shaft.

   Inputs to these indicators came from autosyn generators mounted in the model as position pickups by use of a cable, reel, and take-up spring. Thrust, drag, and moment readouts are force as well as position readings because of the spring restraints to

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   d. Model collective pitch angle

   e. Model rolling moment

   f. Model pitching moment

   g. Gyro roll angle with respect to the rotor shaft

   h. Gyro pitch angle with respect to the rotor shaft.

   Inputs to these indicators came from autosyn generators mounted in the model as position pickups by use of a cable, reel, and take-up spring. Thrust, drag, and moment readouts are force as well as position readings because of the spring restraints to

e. Two strain-gage bending, measuring mid-span flap bending and outboard flap bending respectively, located on the same blade at Stations 22 and 44.

f. One strain-gage torsion bridge, measuring mid-span torsion, located on the same blade as e. at Station 22.

g. One strain-gage bending bridge, measuring mid-span chord bending, located on the same blade as e. and f. at Station 22.

The non-rotating information channels were as follows:

a. Eight rotary potentiometers were mounted on the same shafts as the eight autosyn transmitters described in the section on model situation display instrumentation and recorded the same eight model conditions of (a) thrust, (b) drag, (c) pitching attitude, (d) collective pitch, (e) rolling moment, (f) pitching moment, (g) gyro roll angle, and (h) gyro pitch angle.

b. Three model body velocity pickups were mounted in the model parallel to the shaft, to a longitudinal centerline ($\perp$ to the shaft), and to a lateral centerline ($\perp$ to the shaft) with their active axes passing as close to the model c.g. as was physically practical. Unfortunately, the vertical pick-up had to be loacated aft and to the left about 4 inches from the c.g. For the freon testing, the velocity pickups were replaced by accelerometers.

c. The 28th channel of information consisted of the output from a non-rotating magnetic pickup mounted so that a steel button on the rotor shaft chain sprocket came in close proximity once per revolution of the rotor. The button was so positioned that the resulting "spike" on the oscillograph record occurred when the #1 rotor blade was in the 180°, or straight-forward, position.

No amplification was used on any of the signals fed to the oscillographs.

The power supply cart for instrumentation and model control power is shown in Figure 17. This cart contained storage batteries which automatically provided emergency power in case of failure of the normal power source.

Details of the routing and securing of the rotor wiring are shown in Figures 19 and 20.

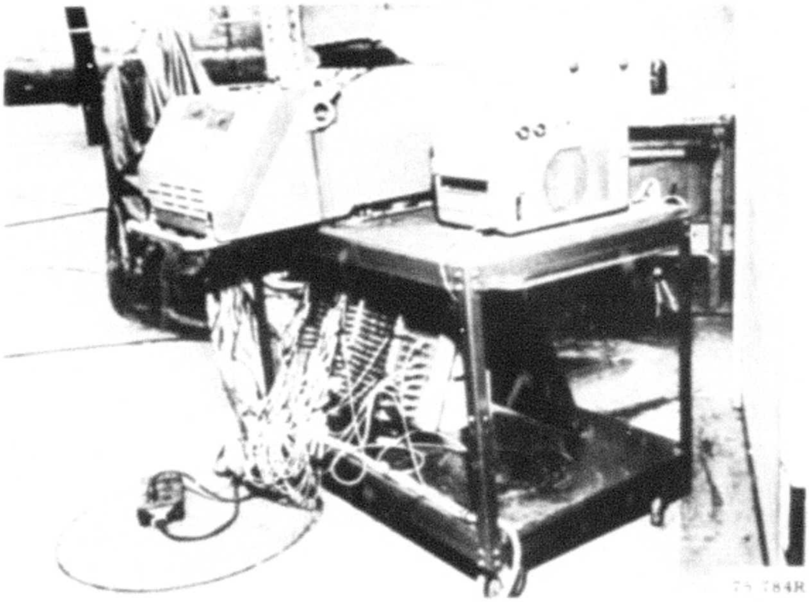

FIGURE 16 OSCILLOGRAPH CART

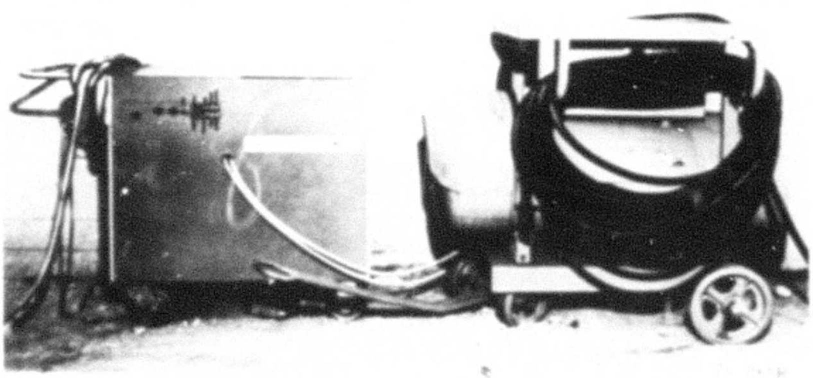

FIGURE 17 POWER SUPPLY CART

FIGURE 18 MODEL OPERATING AT BURBANK, COWLING OFF

Note: Body degrees of freedom blocked(Not blocked during FST or TDT).

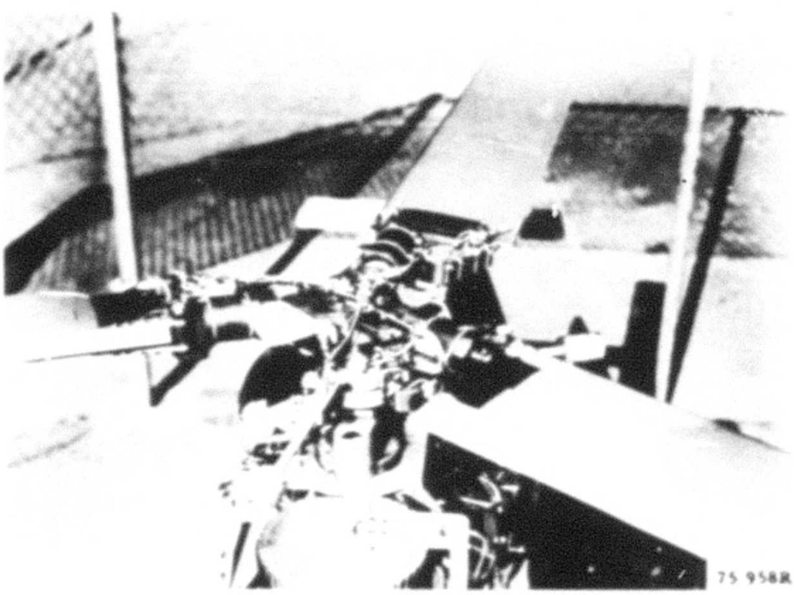

FIGURE 19 ROTOR CLOSEUP FROM ABOVE

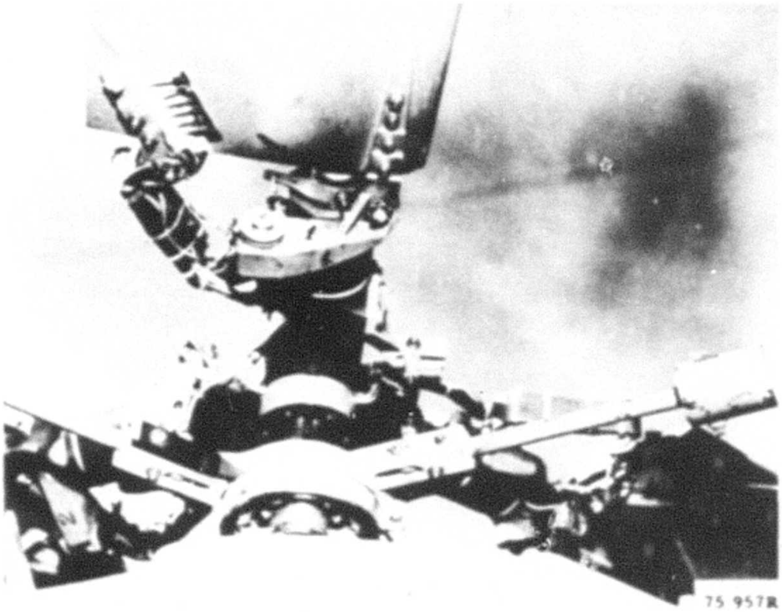

FIGURE 20 ROTOR CLOSEUP FROM BELOW

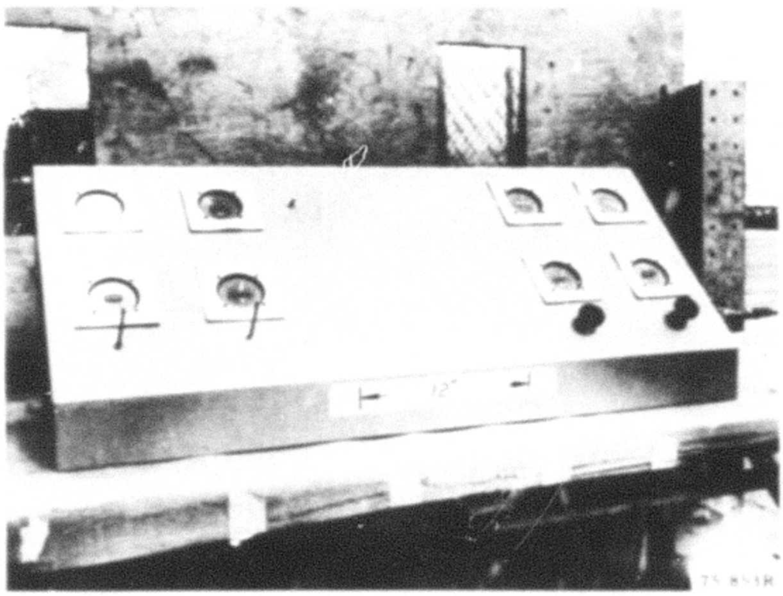

FIGURE 21 MODEL OPERATOR'S CONSOLE

VI. WIND TUNNEL TESTS

Wind tunnel tests were conducted on the model using the fiberglass blades, the 0° twist aluminum blades, and the -8° twist aluminum blades in a total of seven different rotor dynamic configurations in November and December 1962 in the Langley Full Scale Tunnel of the NASA. These tests involved speeds up to 106 miles per hour and load factors up to +2.0. Additional tests were conducted on the two aluminum blade configurations in May 1963 in the Langley Transonic Dynamics Tunnel (TDT) of the NASA to speeds as high as 240 miles per hour (simulated in standard air).

A. TEST PROCEDURE

The testing procedure used in this program is totally dependent on having a rotor - model combination that is stable in the wind tunnel. The wind tunnel model tends to be considerably less stable than the same dynamic configuration would be in free flight becau- e the model has neither speed, stability, nor the damping due to axial velocity of the rotor from disturbances in free flight.

The cyclic trim systems in the model provide only the capability for the operator to trim out undesired steady-state model pitch and roll moments. The response of the systems is not rapid enough to allow the operator to "fly" even a neutral or "zero" stability configuration. Stability of the rotor-gyro model system must be (and was) positive for any configurations tested.

In rigid-rotor model testing, it is dangerous to rotor integrity to operate out of trim with respect to pitch and roll moments, as the rotor has the ability to generate much greater moments when the model is against a pitch or roll "stop" than the rotor could ever encounter in free flight.

Due to the considerations detailed above, it is necessary that none of the parameters listed below be varied more rapidly than their respective effects on trim can be canceled out by the operator's pitch and roll trim systems. These parameters in an approximate order of their effect on trim are:

1. Collective pitch (very sensitive at high "q").

2. Model attitude (fairly sensitive at high "q").

3. Rotor RPM (loss of model power at high "q" with resulting sudden deceleration in RPM can be disastrous, as the trim control power decreases just when it is most needed).

4. Tunnel velocity - except in the low-speed transition region. The sensitivity to changes in tunnel "q" was very low.

Control of the model was exercised by one or two "model operators" in addition to one man who controlled the model motor settings and monitored rotor RPM, and another person who controlled the wind tunnel "q". The "model operator" controlled the model pitching attitude, collective pitch, and model pitch and roll trim in addition to monitoring thrust, drag, and gyro pitch and roll attitudes. The operational procedure was as follows:

1. Bring the rotor up to operating speed.

2. Bring the tunnel up to the desired speed.

3. Adjust the model attitude and collective pitch to give the thrust and drag desired (normally 1 "g" lift and zero drag).

4. Make a final adjustment of roll and pitch trim to zero.

5. Record the 1 "g" data from the balance and the model instrumentation.

6. Without changing collective pitch, decrease model attitude until lift is .5 "g", drag is not zero, and trim pitch and roll are zero. Record the .5 "g" data.

7. Again without changing collective pitch, increase the model attitude until lift is 1.5 "g" and record the data.

8. Repeat for 2.0 "g"; then repeat steps 2. through 7. for the next higher tunnel speed.

At each data point recorded in the FST, oscillograph data records were taken with the gyro both locked and unlocked. Since locking appeared to make no appreciable difference in the data, only gyro-unlocked data were taken in the TDT.

The trimmed gyro-locked condition is equivalent to a conventional swashplate, which suggests that this reported data is applicable to a non-gyro-controlled rigid-rotor helicopter. When examining helicopter characteristics which involve deformation of the rotor system, this conclusion appears to be valid.

However, the model was tested while being supported through a system of springs which allowed only limited travel of the fuselage rigid body degrees of freedom. These restrictions and the fact that Froude number was not matched by the present scaling do not allow a comparison of free-flight vehicle characteristics to be made between the swashplate and gyro-controlled helicopter from these test results. Section V discusses the model properties and simulation.

B. TEST RESULTS AND DISCUSSION

The rotor configurations tested are outlined in Table 3. The data obtained are tabulated in Tables 11 through 22. Instrumentation sensitivities (or calibration factors) are given in Tables 5 through 10.

Tables 11 through 22 are reported as the appendix of this report. A complete index of this appendix is given in Table 4. Because it was difficult to predict at the start of the program exactly what measurements would be most valuable, a great deal of information was collected which on subsequent examination did not appear to be of sufficient interest to justify detailed examination at this time. The pitch link loads which measure blade feathering torque, drag link loads which measure blade chordwise loading, and model body vibration as measured by velocity or acceleration pickups appeared, upon examination of the oscillograph records, to be the most interesting results and are reduced and presented in detail. The rest of the data is included in Tables 11 through 22, along with all the information needed by the reader to reduce and examine any data in which he may be interested. When not otherwise indicated, rotor Configurations A through H are operating at the nominal speed of 1055 RPM. Similarly, rotor Configurations J through M are operating at the nominal speed of 576 RPM. In all cases where V_M or V_{M_P} is not shown, the speed is approximately zero.

Vibration results are reported as $\frac{\text{peak to peak}}{2}$, and no further attempt is made to determine harmonic content of the oscillograph records for the following reasons: (1) velocity and acceleration pickups of very wide frequency range were used, and consequently a great deal of high-frequency vibration ("hash") was recorded; (2) this "hash" shows strong first harmonic content of the rotational speed of the synchronous motors; and (3) the vibration levels recorded were aggravated by the proximity of the second flap bending frequency of the blades to 3P.

As a result of the above considerations, the vibration data offer a basis for comparison of relative merits of configurations rather than supplying actual vibration levels.

FULL SCALE TUNNEL AND TRANSONIC DYNAMICS TUNNEL DATA

The presentation of reduced data, obtained from measured data of the appendix, is found in Figures 24 through 82.

In order that data may be presented more reliably with respect to load factors, cross plots of data versus model attitude were made (Figures 35 through 44 and 61 through 69), and values of data at desired load factors were determined through faired curves drawn through raw data.

TABLE 3 SUMMARY OF ROTOR CO

CONFIGURATION	CONFIGURATION DESCRIPTION	TUNNEL & DATE	GYRO I, SLUG FT.^{2}	SWEEP ANGLE, DEG.	BLADE TWIST	BLADE CONSTRUCTION	D.L. STIFFNESS	HUB STIFFNESS	BLADE/GYRO RATIO	CANT ANGLE*
A	Chord Stiff 0° Twist	FST 11/30 12/4	.059	1.5	0°	Al.	H	N	1.30	60°
B	Chord Stiff 8° Twist	FST 12/7	.059	1.5	8	Al.	H	N	1.30	60°
C	Matched 8° Twist	FST 12/7	.059	1.5	8	Al.	M	N	1.30	60°
D	Matched Low Gyro	FST 12/7	.006	1.5	8	Al.	M	N	1.30	60°
E	Glass Blades	FST 12/11 12/13	.006	1.5	0	Gl.	M	N	1.30	60°
F	Soft Hub	FST 12/19	.006	1.5	8	Al.	M	L	1.30	60°
G	3° Sweep	FST 12/19	.006	3.0	8	Al.	M	N	1.30	60°
H	Unloaded Rotor	FST 12/20	.006	1.5	8	Al.	M	L	1.30	60°
J	Matched 8° Twist	TDT 5/7	.013	3.0	8	Al.	M	N	1.06	
K	Matched 8° Twist	TDT 5/8	.023	2.0	8	Al.	M	N	1.06	
L	Matched 0° Twist	TDT 5/14	.023	2.0	0	Al.	M	N	1.06	
M	Matched 0° Twist	TDT 5/15	.023	2.0	0	Al.	M	N	1.06	

M= Matched Stiffness, H= High Chord Stiffness, * +5° Due to Torsionally Soft Gyro
FST= 30' x 60' or Full Scale Tunnel, TDT = 16' x 16' Transonic Dynamic Tunnel, A
Gl.= Fiberglass Blades, N= High Hub Stiffness, L= Low Hub Stiffness

FIGURATIONS

RUN NUMBER	CHANGED SINCE LAST DATE	REMARKS
17 20	2.5" Long Shims Between Hub and Doubler Plates	Data to 106 MPH & 2.5 "g" "Pitch Up Incident" see V (c)
21	Chg'd Roll Moment Sensitivity	106 MPH and 2.0 "g"
22		106 MPH and 2.0 "g"
23		To 106 MPH and 2.0 "g"
24 27	New Pitch Links	To 106 MPH and 2.0 "g" #3 Blade Failed see V (c)
28	Straightened #1 Hub Spindle	To 106 MPH and 2.0 "g"
29	Replaced Timing Belts	To 106 MPH and 2.0 "g"
30		To 106 MPH not Trimmed in Drag
31	Hub Flap Stiffness Chg'd	To 25 "g" and 1.0 "g"
32	Increased Gyro	To 28 "g" and 1.5 "g" Lost Model Power see V (c)
33		Excessive Gyro Wobble (Blades Out of Track) Data to 36 "q" and 1.0 "g"
35	Chg'd Vertical Springs in Model	Data at .5 "g" Not drag trimmed to 90 "q" Model Mount Failed (see V c) at 106 "q"

Drive,
. = Aluminum Blade,

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Drag link and pitch link loads versus model velocity for various load factors are given for Configurations A through H in Figures 24 through 34. Although these oscillating loads were principally first harmonic, the $\frac{\text{peak to peak}}{2}$ values have been plotted which represent the total oscillating loads.

Steady-state thrust and peak-to-peak oscillating loads are plotted versus model attitude for Configurations A through K in Figures 35 through 44. The test procedure which yields these results is described on [illegible] of this report.

Comparative plots of drag link and pitch link $\frac{\text{peak to peak}}{2}$ load data for seven rotor configurations are presented in Figures 45 through 51. Figures 45 through 49 present plots of these loads versus model velocities up to 106 miles per hour, while Figures 50 and 51 present plots of these loads versus load factor at 106 miles per hour. Drag link loads appear to be independent of gyro inertia (Figure 47), blade sweep, and hub flap stiffness (Figure 49) in the 50 to 106 miles-per-hour model velocity range. The highest drag link load is exhibited by Configuration A, while, in comparison, Configuration B exhibits 70 per cent, Configurations C and D exhibit 30 per cent, and Configuration E exhibits 10 per cent in the 50 to 106 miles-per-hour range.

Drag link loads vary linearly with load factor and are approximately zero at zero load factor. Figure 33 reports TDT drag link load data where good correlation with FST data is observed.

Pitch link loads appear to be independent of blade sweep and hub flap stiffness (Figure 49) and drag link stiffness (Figure 4[illegible]). With the exception of the fiberglass blade, which showed higher loads at 25 miles per hour, all the configurations show very close to the same pitch link loads at 25 miles per hour and are within ±15 per cent at 106 miles per hour (Figures 45, 47, and 48). Approximate linear variation of pitch link loads with load factors is exhibited in Figures 50 and 51.

Pitch link load data for Configurations L and M in the TDT were reduced using the calibration of 7 May, since the 13 May calibration appears to be in error. To account for the difference in blade gyro ratios between TDT and FST data, the TDT pitch link loads were multiplied by 1.23 (Figure 33). Good correlation with FST data is also shown for pitch link load data in this figure.

Lateral vibration levels were highest in Configurations A, E, and G (Figures 52, 56, and 58, respectively). Comparison of the lateral vibration levels at 106 miles per hour of all configurations indicates lowest levels were attained by twisted metal blades with soft drag links. Except for Configuration D, Figures 75 and 76 indicate increase of lateral vibration levels with increasing load factors at 106 miles per hour. TDT vibration readings indicated that lateral vibration levels are no higher than hovering levels up to 140 miles per hour.

Longitudinal vibration $(\frac{\text{peak to peak}}{2})$ readings fell between .01 and .02 fps in the FST tests except for Configurations E and F. Configuration E indicated higher levels at all model speeds, while Configuration F indicated increasing levels with increasing model velocity. Figures 75 and 76 indicate no appreciable change of longitudinal vibrations with increasing load factor except for Configuration E, which indicated increasing levels. In the TDT, longitudinal vibrations did not change from hovering values up to velocities of 140 miles per hour.

Vertical vibrations were between $(\frac{\text{peak to peak}}{2})$ values of .01 and .02 fps for all configurations except E and G, which were 50 per cent higher. Rotor configurations and load factors did not affect vertical vibration levels (Figures 75 and 76).

Model support springs were changed for Configuration M to larger values as shown in Figure 13, to reduce observed response amplitudes of the model.

In order to obtain data for a compound helicopter, the model was tested at 0.5g in the TDT at high speeds (Figure 33). The highest simulated speed achieved was 240 miles per hour. These tests were terminated because of model mount failure. The model has now been repaired and a follow-on study is in progress.

C. TEST INCIDENTS AND FAILURES

During the wind tunnel testing, four incidents occurred which caused varying degrees of damage to the model.

1. Pitch-up Incident - While running Configuration A at 10? miles per hour with the attitude nose up to obtain 2.5 "g", the model pitched nose up against the pitching moment stop. This created about 2.8 or more "g" and very large nose-up moment on the rotor. The high flap bending loads on the hub at this combination of high load factor and high rotor moment caused the doubler plates which provide part of the hub flapping stiffness to yield. This reduction in stiffness resulted in a decrease in compliance correction $(K_\beta \beta\lambda)$ and therefore a considerable decrease in the static stability of the model. This instability in pitch caused the model to nose up until the body contacted the pitching stop, whereupon the rotor tip path plane continued to pitch up until the blade tips struck the tail cone. A contributing factor to this incident was the failure of the autosyn generator which transmitted model pitching moment to the operator's console. The result of this failure was that the

pitching moment indicator continued to show near-zero pitching moment while the model was actually pitching nose up. This incident emphasizes the importance of maintaining pitch and roll trim of the model and thus the dependence of this type of testing on the moment readout system. After this occurence a second, adjustable, nose-up stop was installed in the model with a warning light to show if the model was near or on the stop. This provided a redundant indication of gross pitching moment. The location of the new stop was well forward of the center of lift of the rotor. Thus, when the model pitches up and contacts the stop, the increase in thrust that accompanies the increased angle of attack will rotate the model nose down about the pitch stop.

Damage in this incident, shown in Figure 22, was confined to the tail cone, blade tips, and the removable doubler plates used to vary hub flapping stiffness. The hub itself was not damaged.

2. Glass Blade Failure - After all of the basic fiberglass blade Configuration E tests were completed, an attempt was made to use these blades for the "soft hub" configuration tests. Shortly after the tunnel was started, the #3 blade failed at Station 22 and separated from the model. The cause of this failure was poor design of the blade in that a large change in chordwise stiffness and, therefore, a stress concentration existed at the point of failure. This weakness was aggravated by operation for several minutes at the blade first chord natural frequency while in the process of determining blade frequencies. The fiberglass "D" spar failed progressively toward the leading edge starting at the forward end of the first inboard trailing edge slot. This threw the chord load into the steel "I" spar, which was never intended to be able to carry an appreciable chord load. The "I" spar fatigue failed in bending and departed radially, shredding the fiberglass "D" spar and trailing edge as it left. The blade stub is shown in Figure 23. The resulting 5000-pound rotating unbalance resulted in considerable minor damage to the body shell and instrumentation as well as bending one spindle of the hub. The hub was straightened, magnafluxed and used through the remainder of the program.

3. Model Power Loss - While Configuration K was being run in the TDT at "q" of 40 p.s.f. in a 1.0 "g" drag trimmed (nose down) condition, the power supply to the rotor drive motors failed. The rotor decelerated to less than one-half normal RPM almost instantly. The model pitched nose down and rolled left hard against the stop. Tunnel "q" was cut, the model collective pitch was reduced and the model was nosed up in attitude. However, the model was badly out of trim in roll; and as the rotor continued to slow down, the upper surface of the #3 blade buckled due to excessive up-bending loads between Station 19 and Station 25. This incident emphasizes the danger inherent in any sudden change which affects pitch and roll trim beyond the capability of the operator to retrim. No other damage was found as a result of this incident.

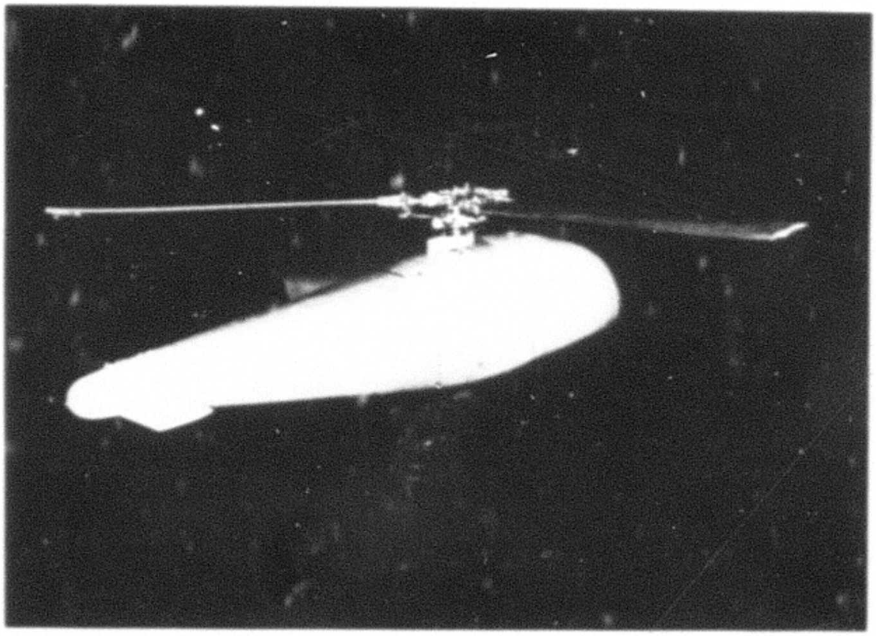


FIGURE 22 MODEL DAMAGE IN PITCH UP INCIDENT

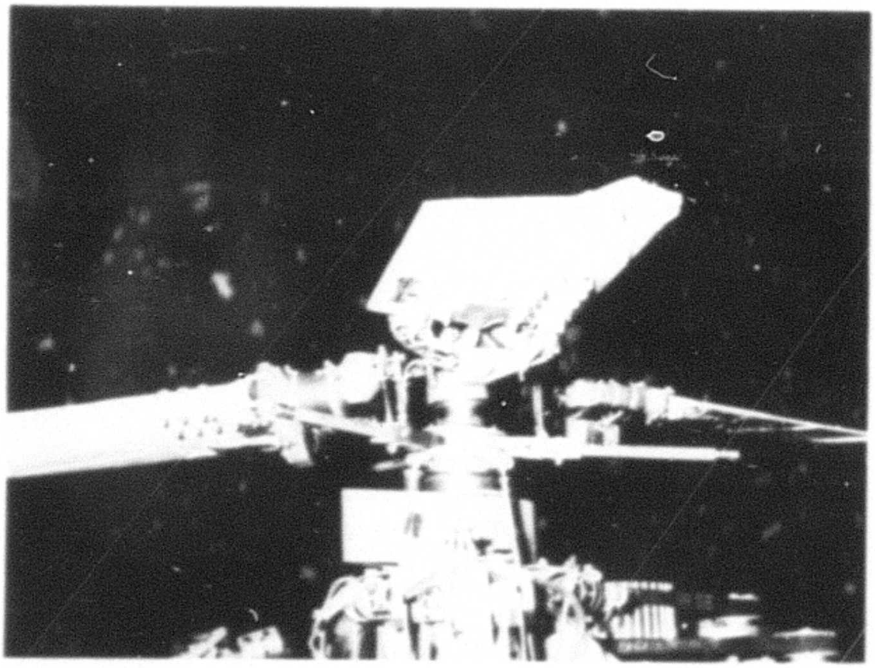


FIGURE 23 ROTOR DAMAGE, FIBERGLASS BLADE FAILURE

4. Model Mount Failure - While Configuration M was being tested at one-half "g" lift and approximately 1-1/2° nose-down attitude (drag untrimmed) at 106 "q" in the TDT, the electromechanical actuator used to position the model pitching attitude parted, thus leaving the model completely free in pitch. The model began to pitch nose up very slowly. This pitching seemed to accelerate until the model was about 30° nose up. The resulting untrimmed pitching moment coupled with the very large lift that would result from 30° angle of attack at 106 "q" apparently was sufficient to shear first the right trunnion bolt and then the left bolt, whereupon the model separated completely from the mount, rolling and yawing to the left and rising slightly as it flew back down the tunnel. It was subsequently determined that the actuator failure was a structural fatigue type of failure. It has not been possible as yet to determine the source of the loading which caused this failure. Two possible causes of the failure are:

a. Accumulated load damage from incidents 1, 2, and 3 above, which resulted in cracks that were not large enough to be found in the disassembly and inspection (no X-rays were taken) of the actuator which occurred prior to the installation of the model in the TDT.

b. Fatigue due to bending loads on the actuator caused by interference within the body.

Because of a time delay in the tunnel balance readout, the data obtained when the model started to go actually represented conditions just prior to the failure and showed that no large or unusual loads were being generated by the model at the time of the failure.

The rotor was almost totally destroyed (although only the tip weights actually detached themselves from the model), and the body shell was badly damaged. However, little, if any, damage was sustained by the internal parts of the model such as the rotor shaft, drive system, instrumentation, and inertia frame.

This appears to have been a structural fatigue failure not related to the particular rotor configuration being tested at the time.

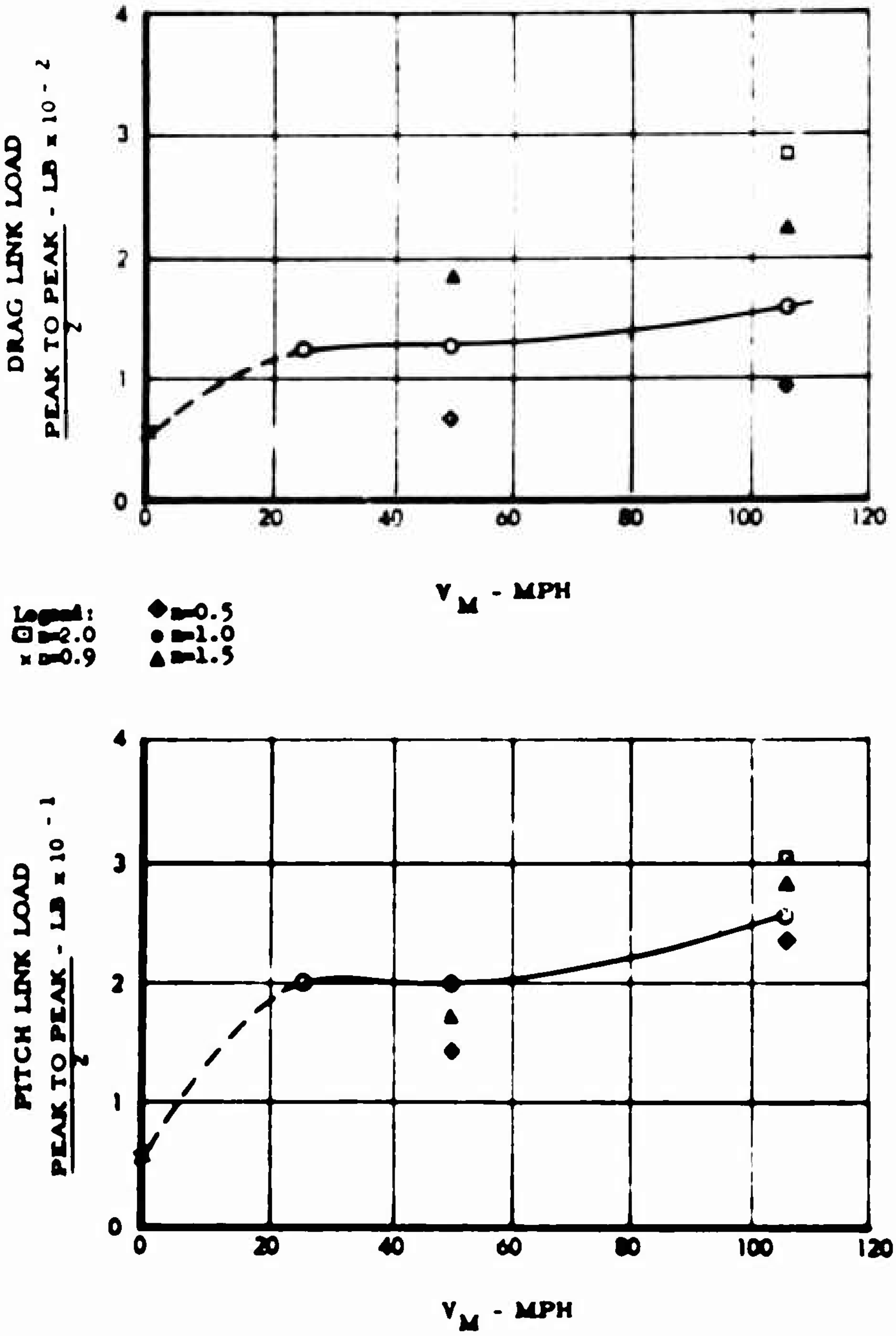
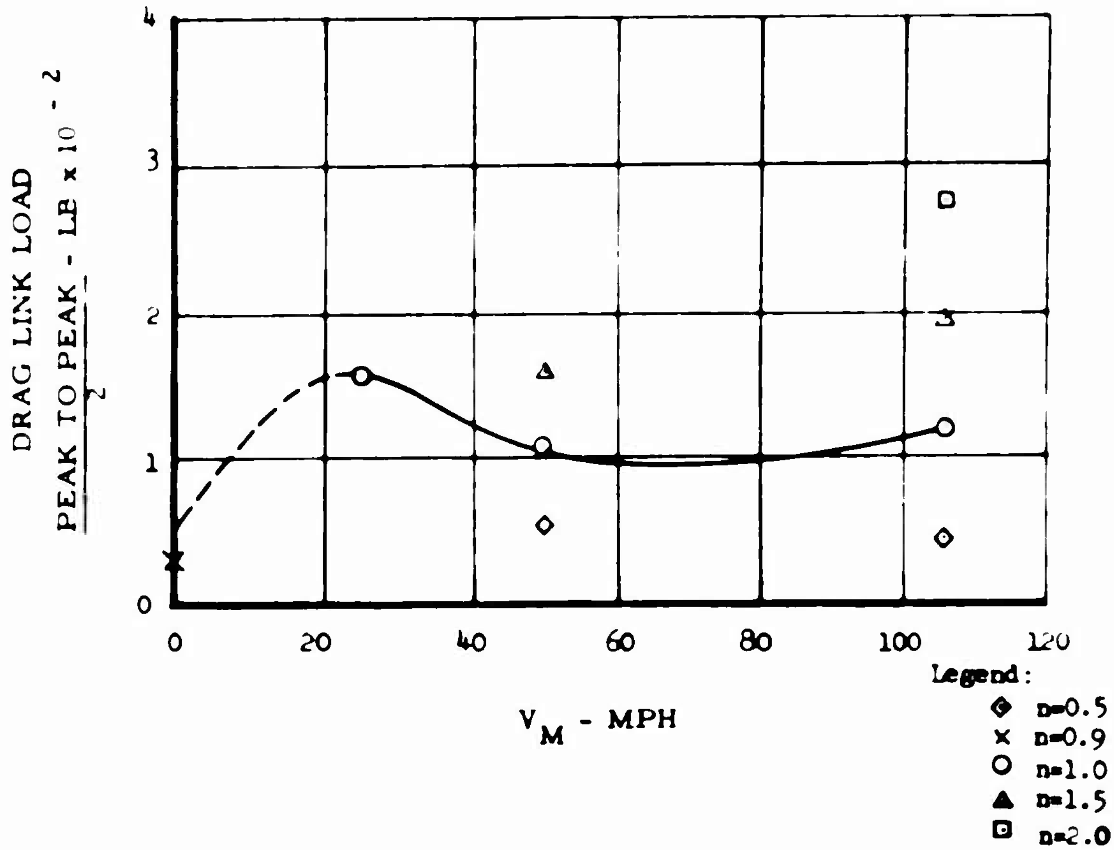


FIGURE 24 DRAG LINK AND PITCH LINK LOADS VS. MODEL VELOCITY FOR CONFIGURATION A



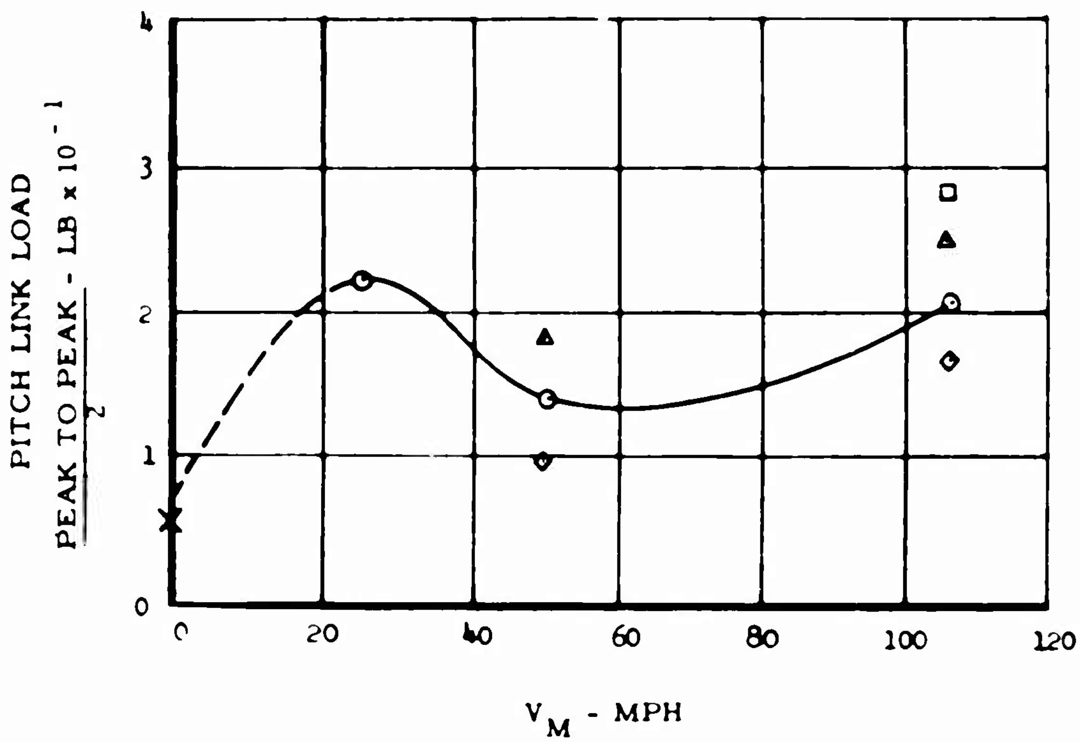


FIGURE 25 DRAG LINK AND PITCH LINK LOADS VS. MODEL VELOCITY FOR CONFIGURATION B

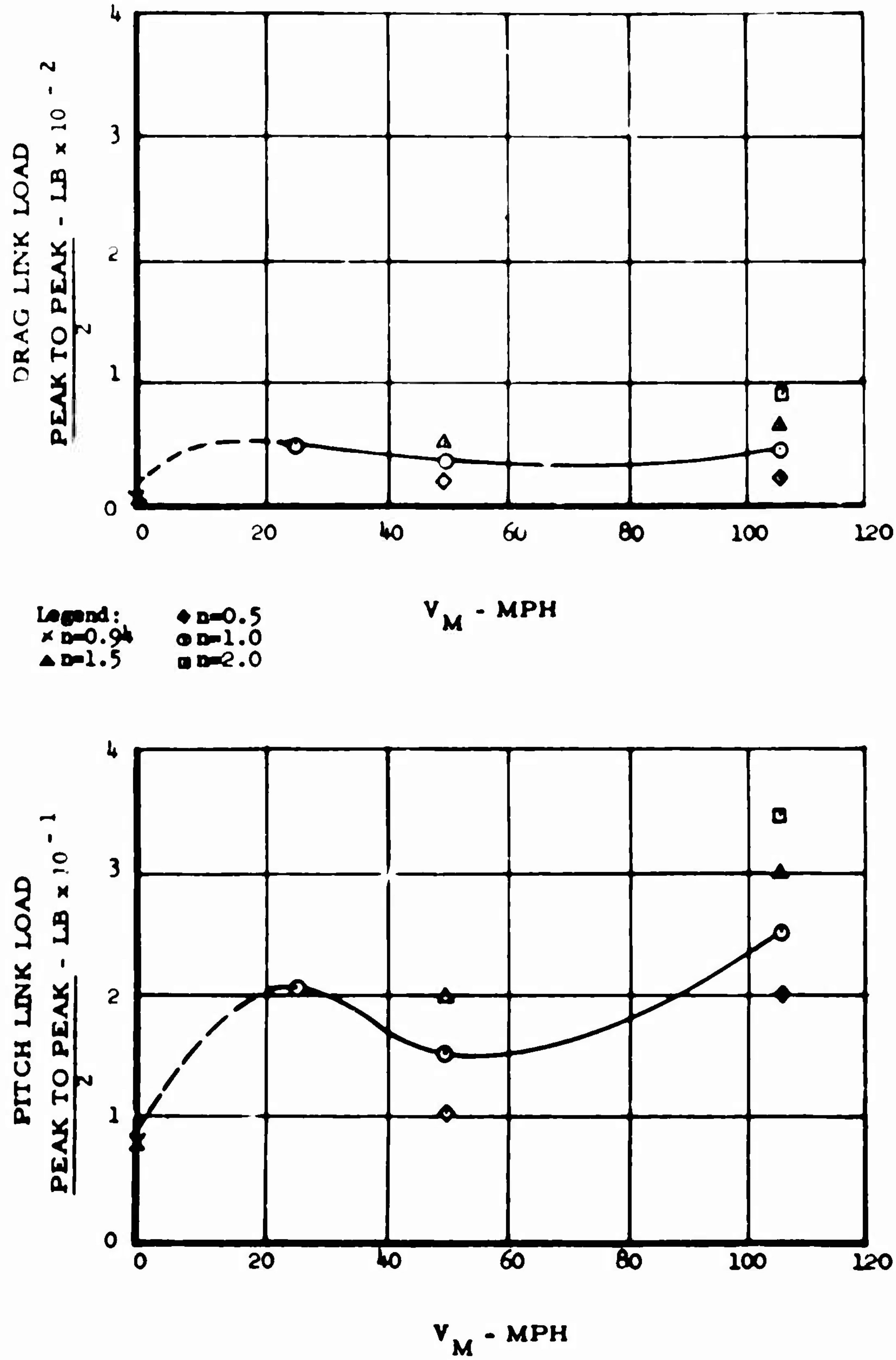
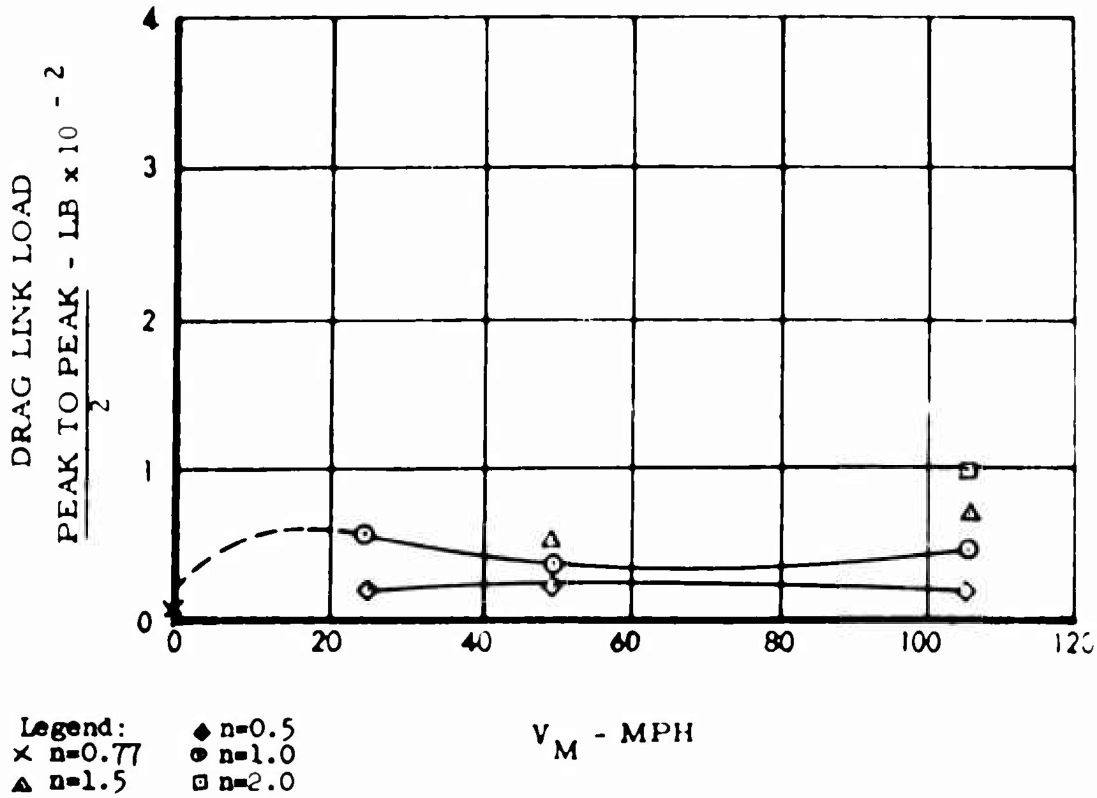


FIGURE 26 DRAG LINK AND PITCH LINK LOADS VS. MODEL VELOCITY FOR CONFIGURATION C



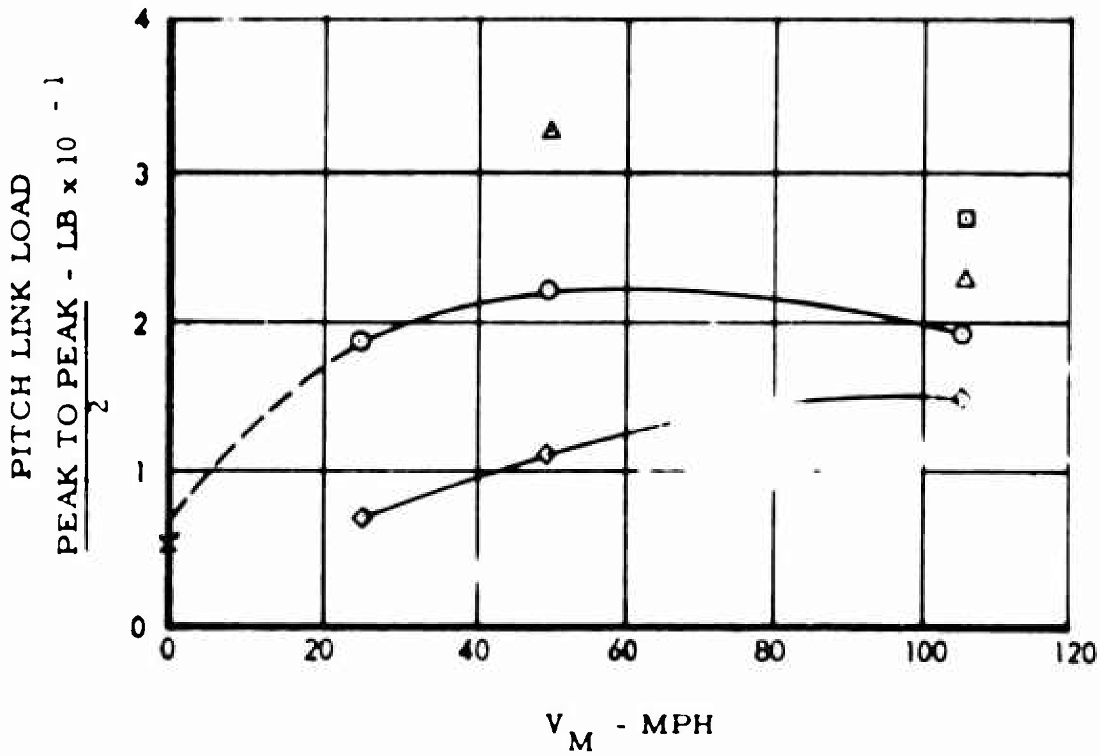
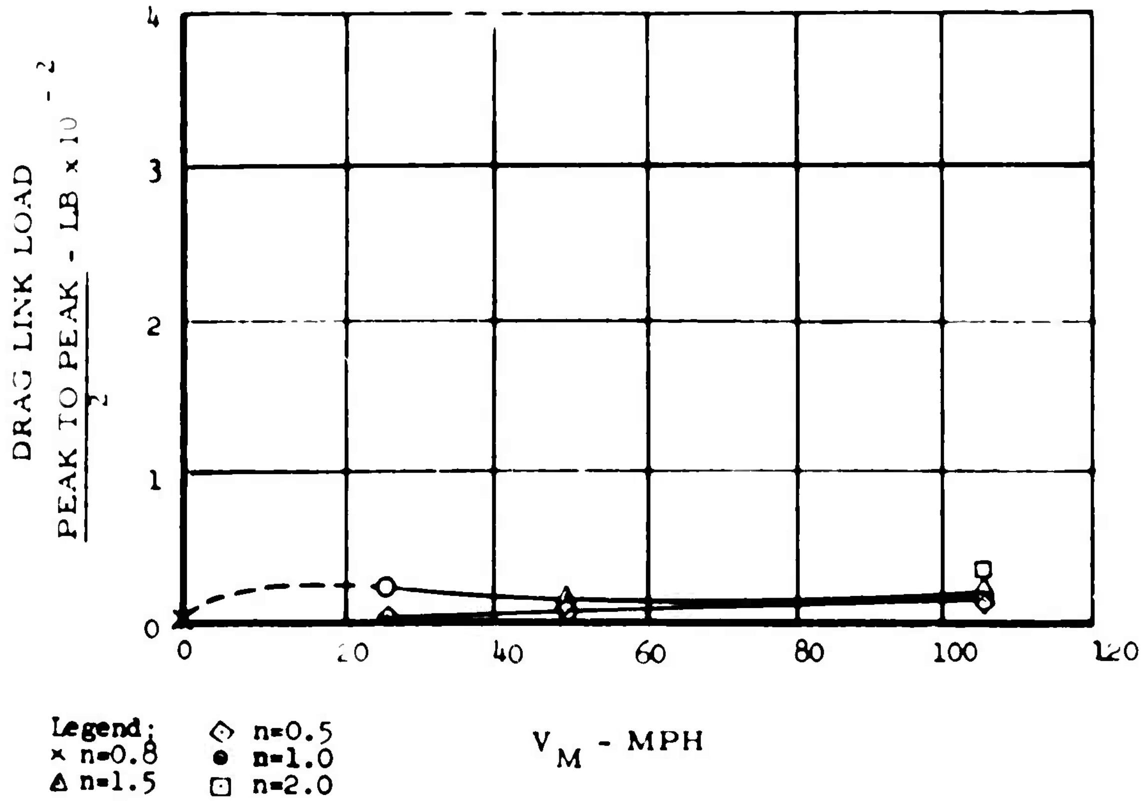


FIGURE 27 DRAG LINK AND PITCH LINK LOADS VS. MODEL VELOCITY FOR CONFIGURATION D



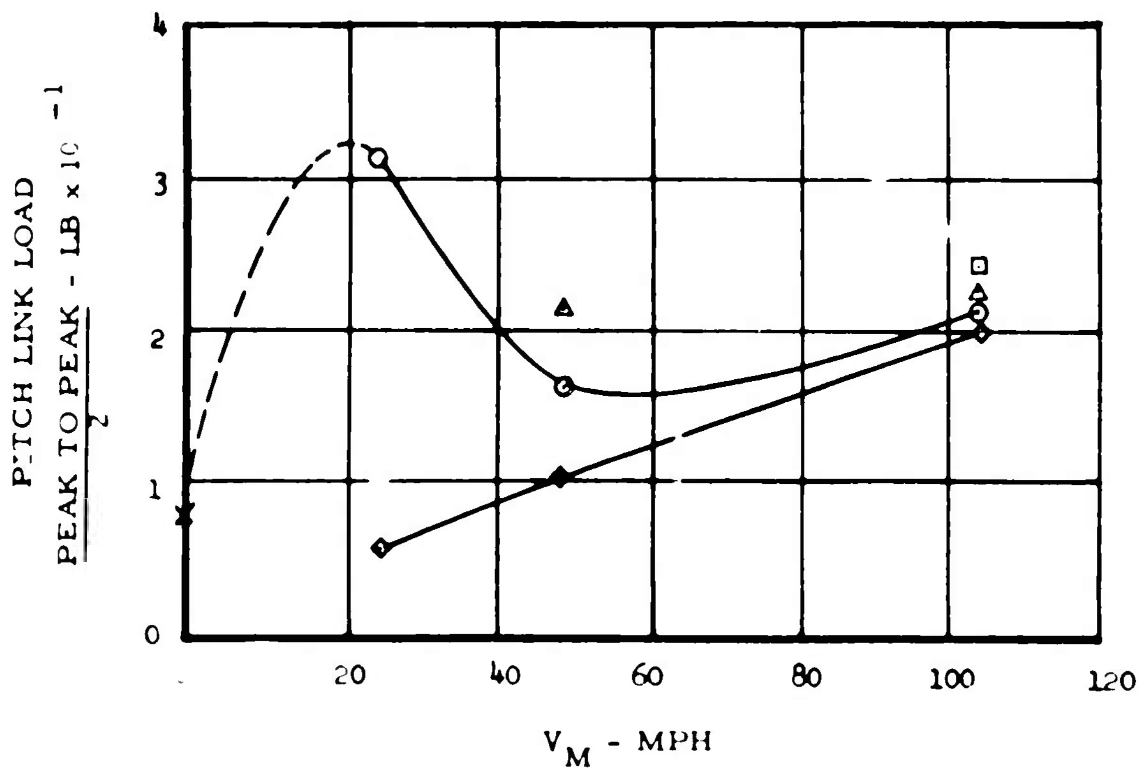
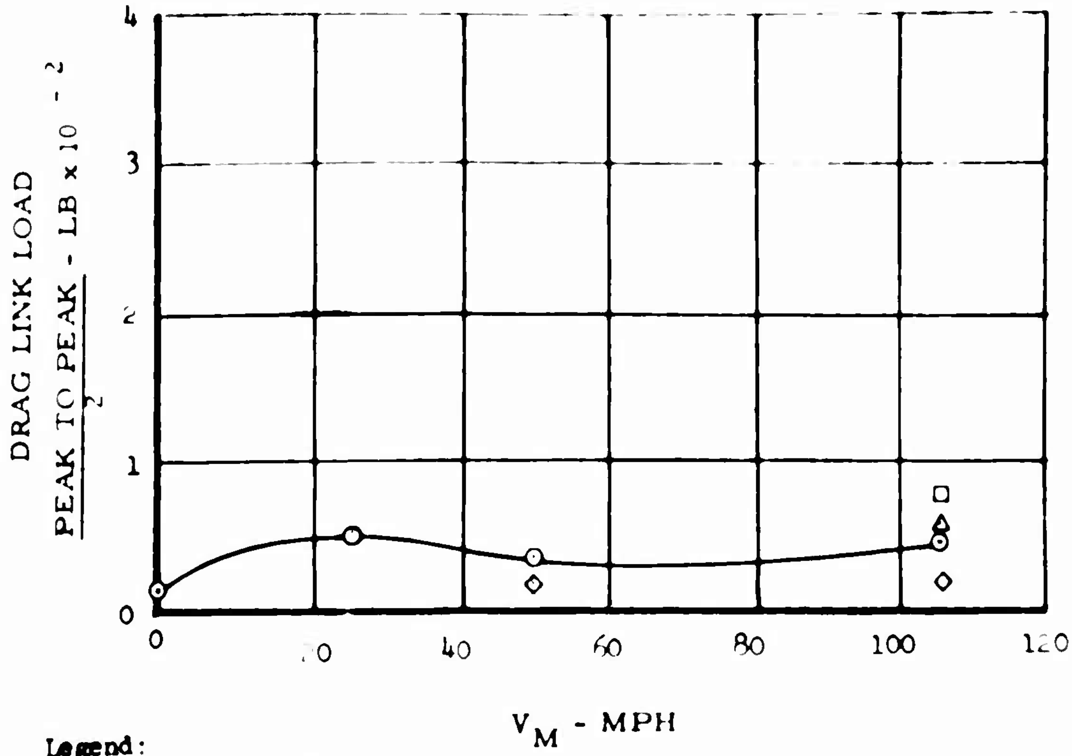


FIGURE 28 DRAG LINK AND PITCH LINK LOADS VS. MODEL VELOCITY FOR CONFIGURATION E



Legend:
◇ n=0.5
⊙ n=1.0
▲ n=1.5
▣ n=2.0

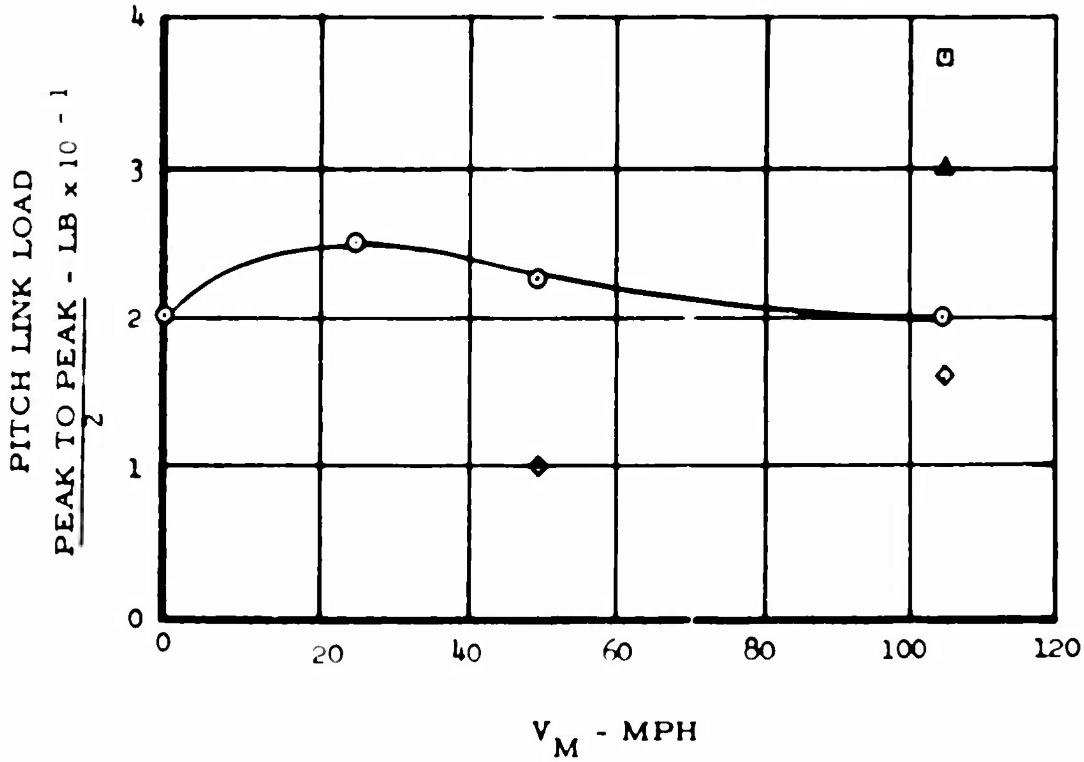
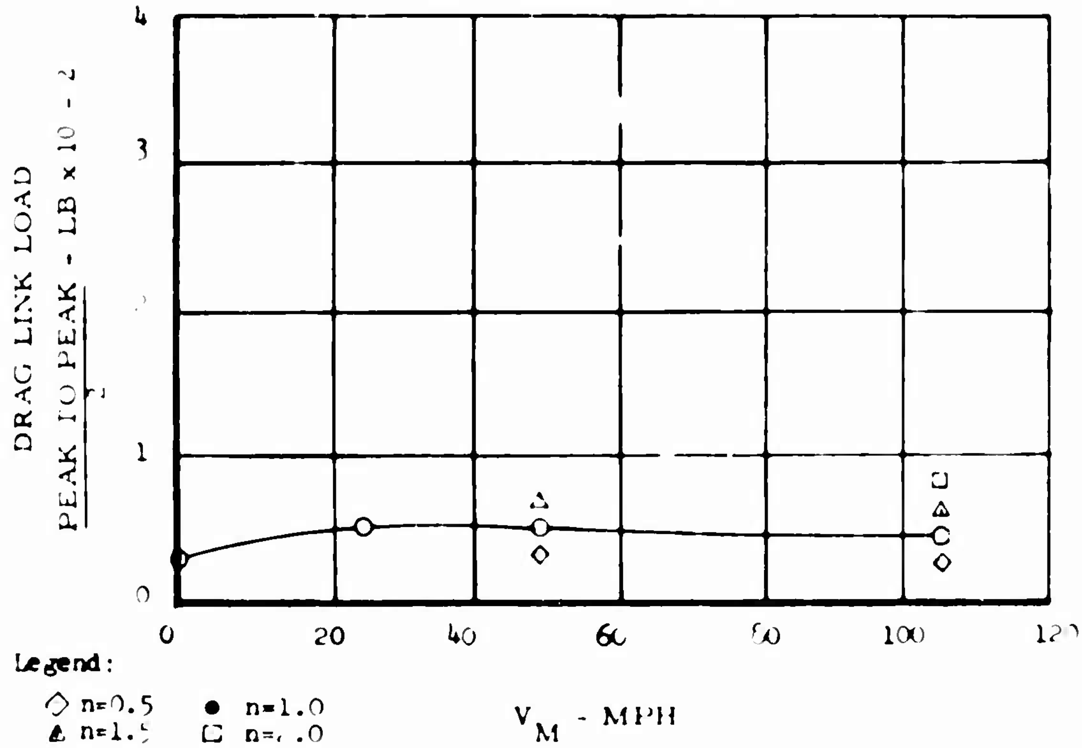


FIGURE 29 DRAG LINK AND PITCH LINK LOADS VS. MODEL VELOCITY FOR CONFIGURATION F



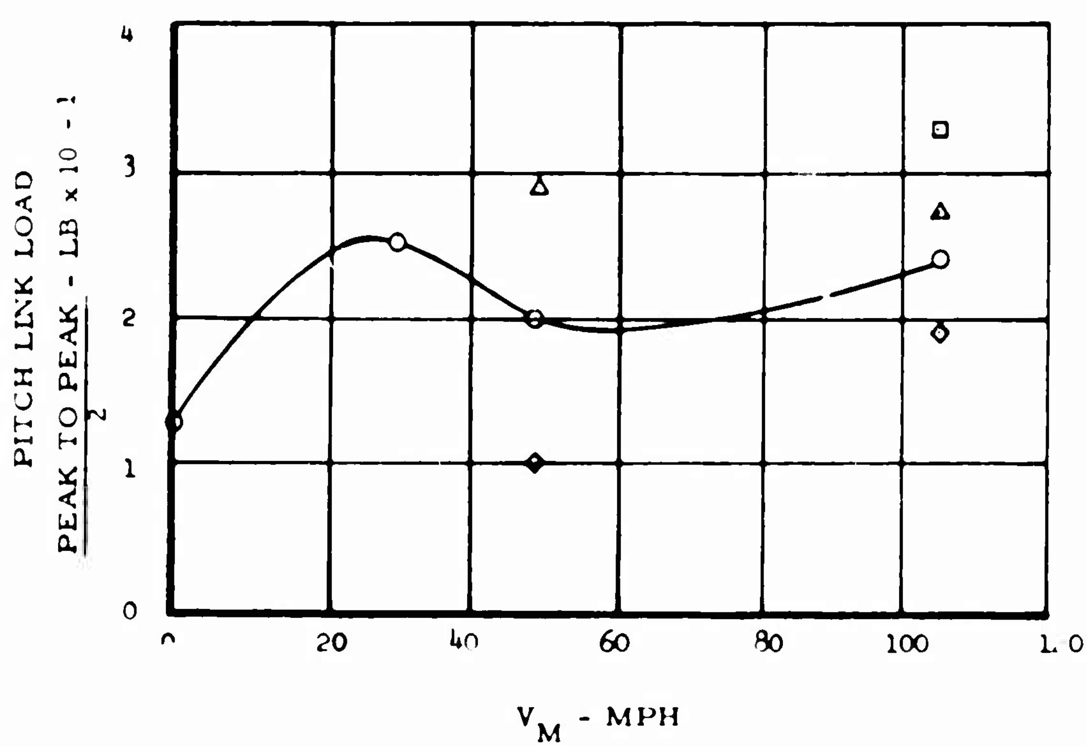


FIGURE 30 DRAG LINK AND PITCH LINK LOADS VS. MODEL VELOCITY FOR CONFIGURATION G

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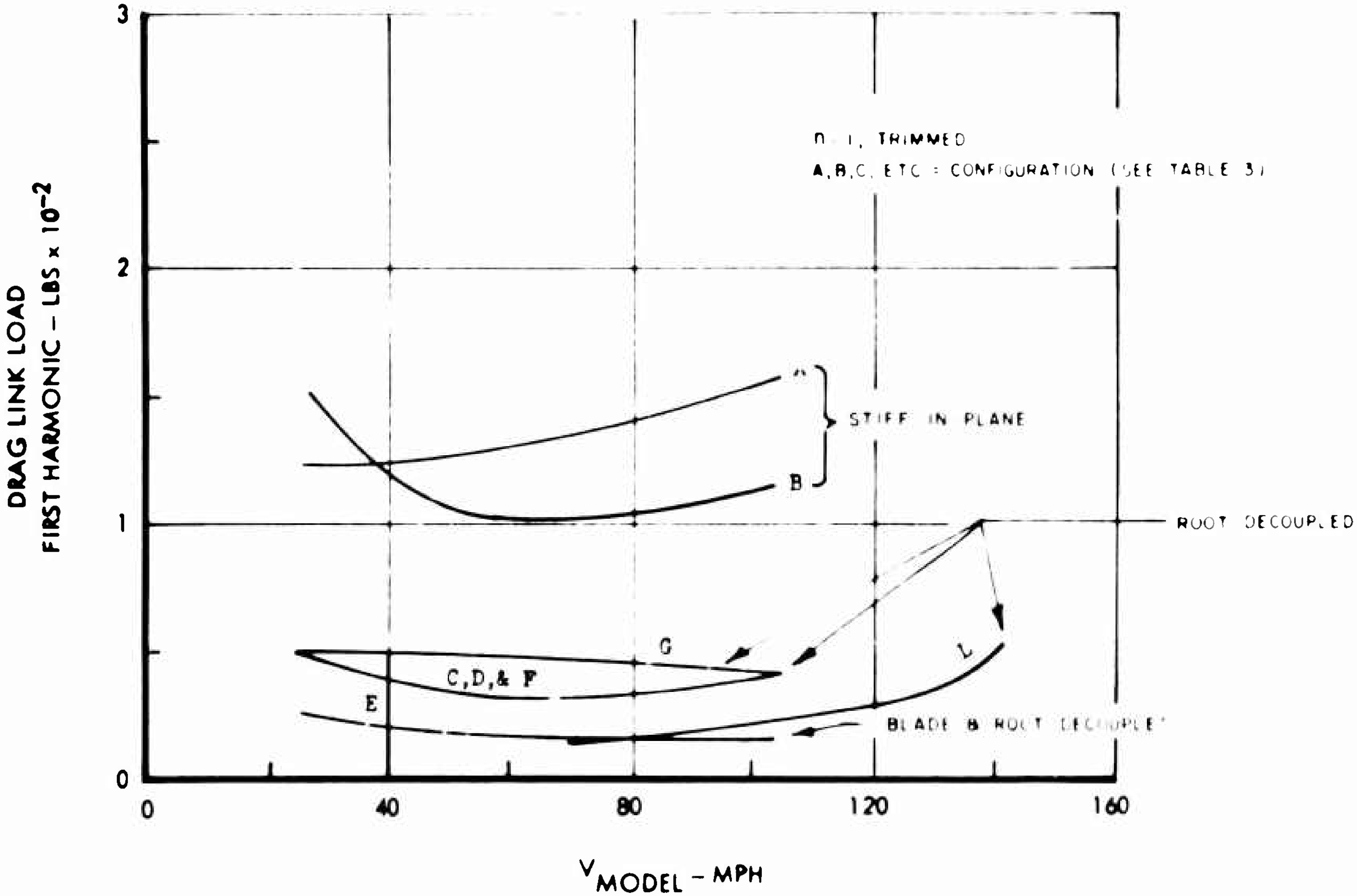


FIGURE 31 DRAG LINK LOAD SUMMARY CURVES

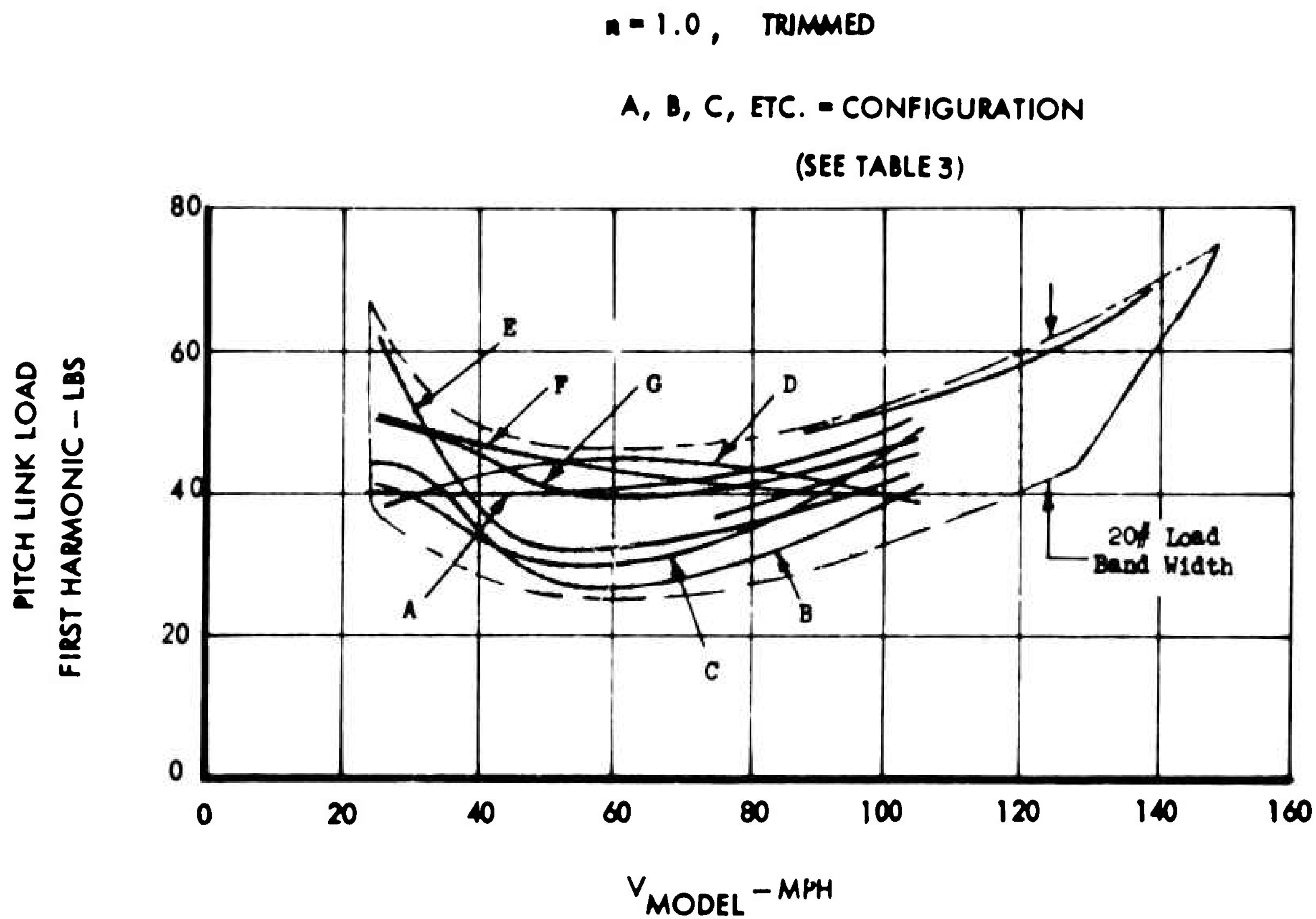


FIGURE 32 PITCH LINK LOAD SUMMARY CURVES

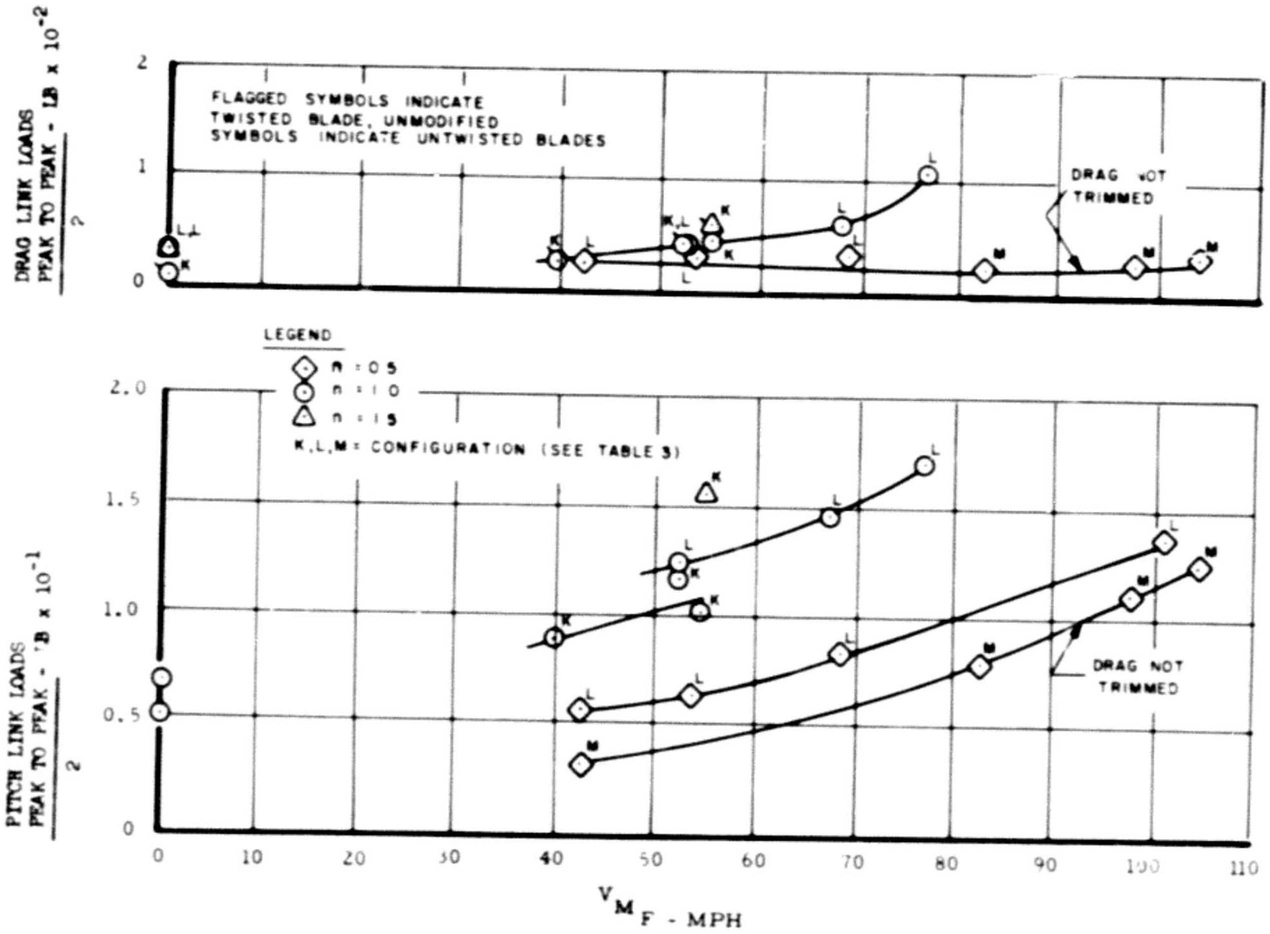


FIGURE 33 D...G LINK A...D PITCH LINK LOADS VS. VELOCITY OF MODEL IN FREON (V_{M_F})

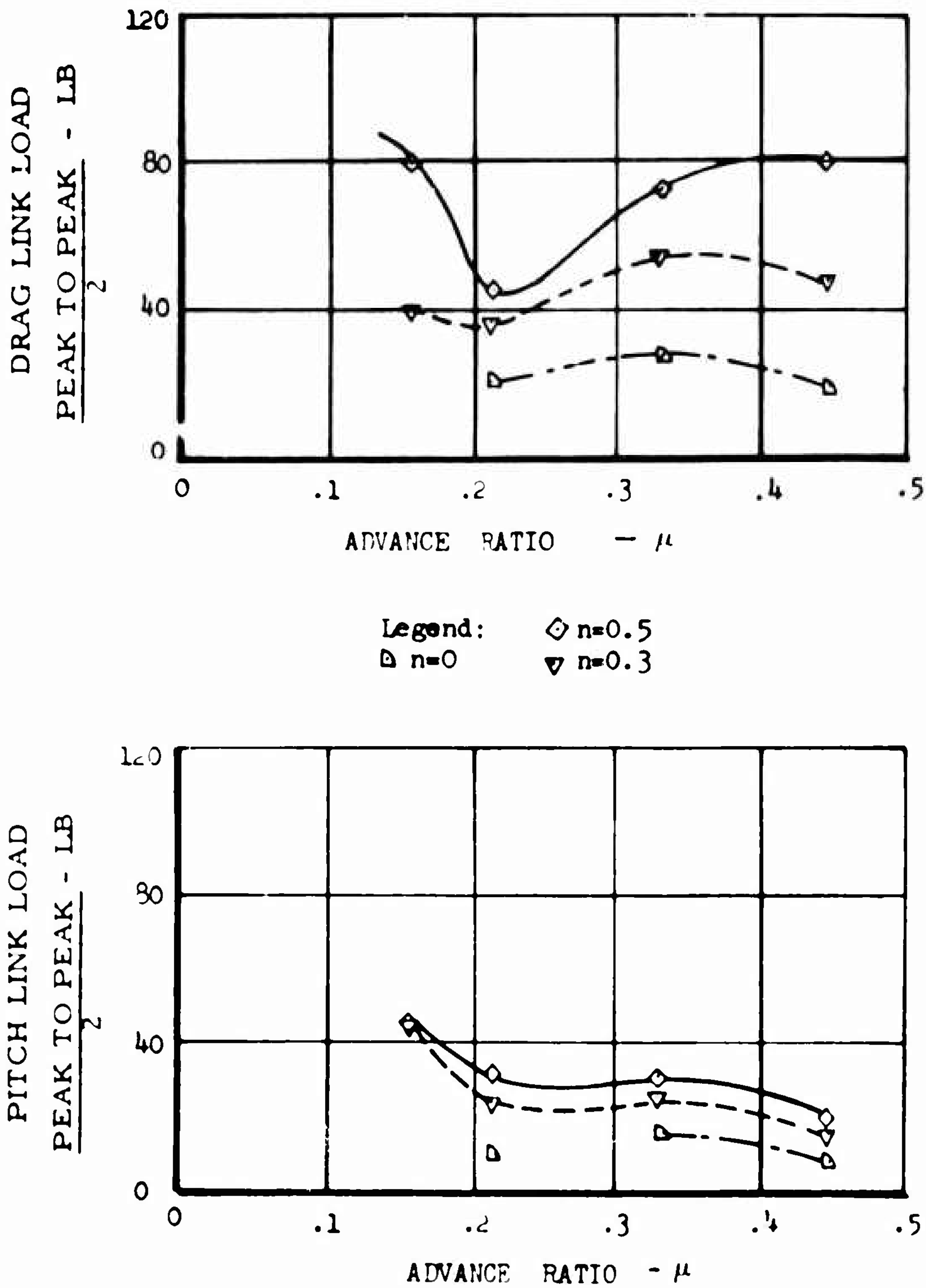


FIGURE 34 DRAG LINK AND PITCH LINK LOADS VS. ADVANCE RATIO FOR CONFIGURATION H

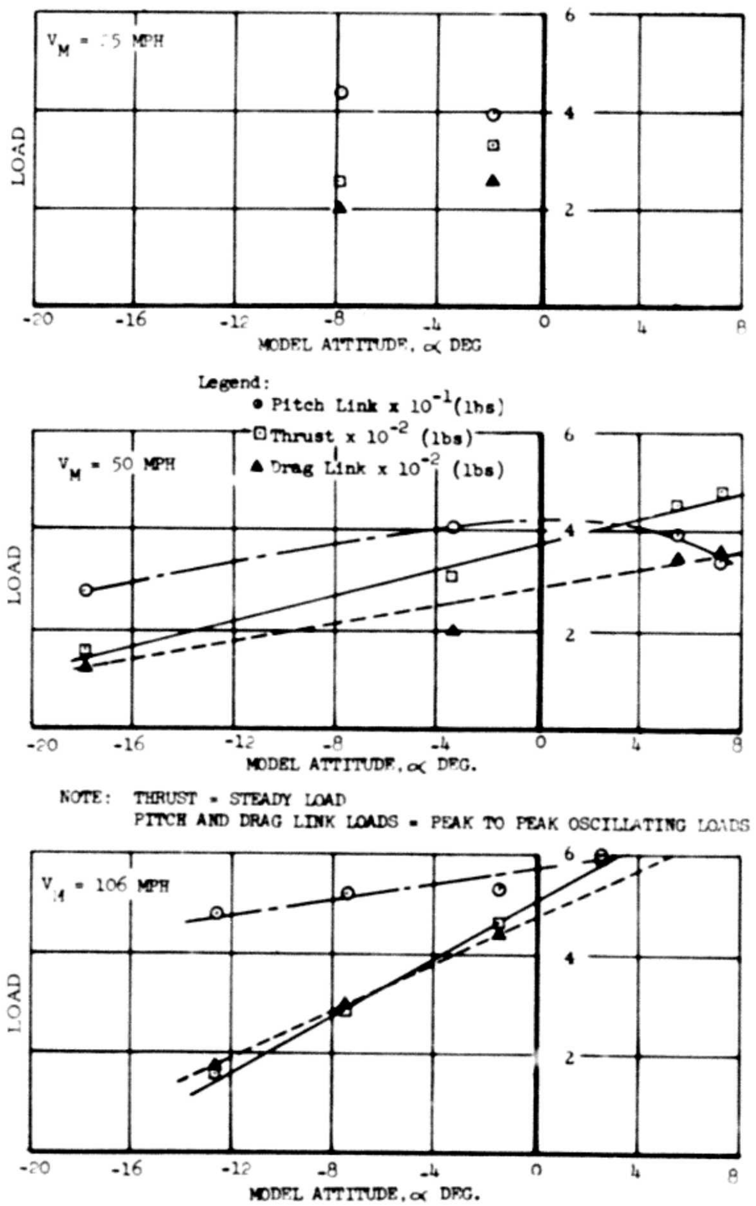


FIGURE 35 THRUST, DRAG LINK AND PITCH LINK LOADS VS. MODEL ATTITUDE - CONFIGURATION A

NOTE: THRUST = STEADY LOAD; PITCH AND DRAG LINK LOADS = PEAK TO PEAK OSCILLATING LOADS

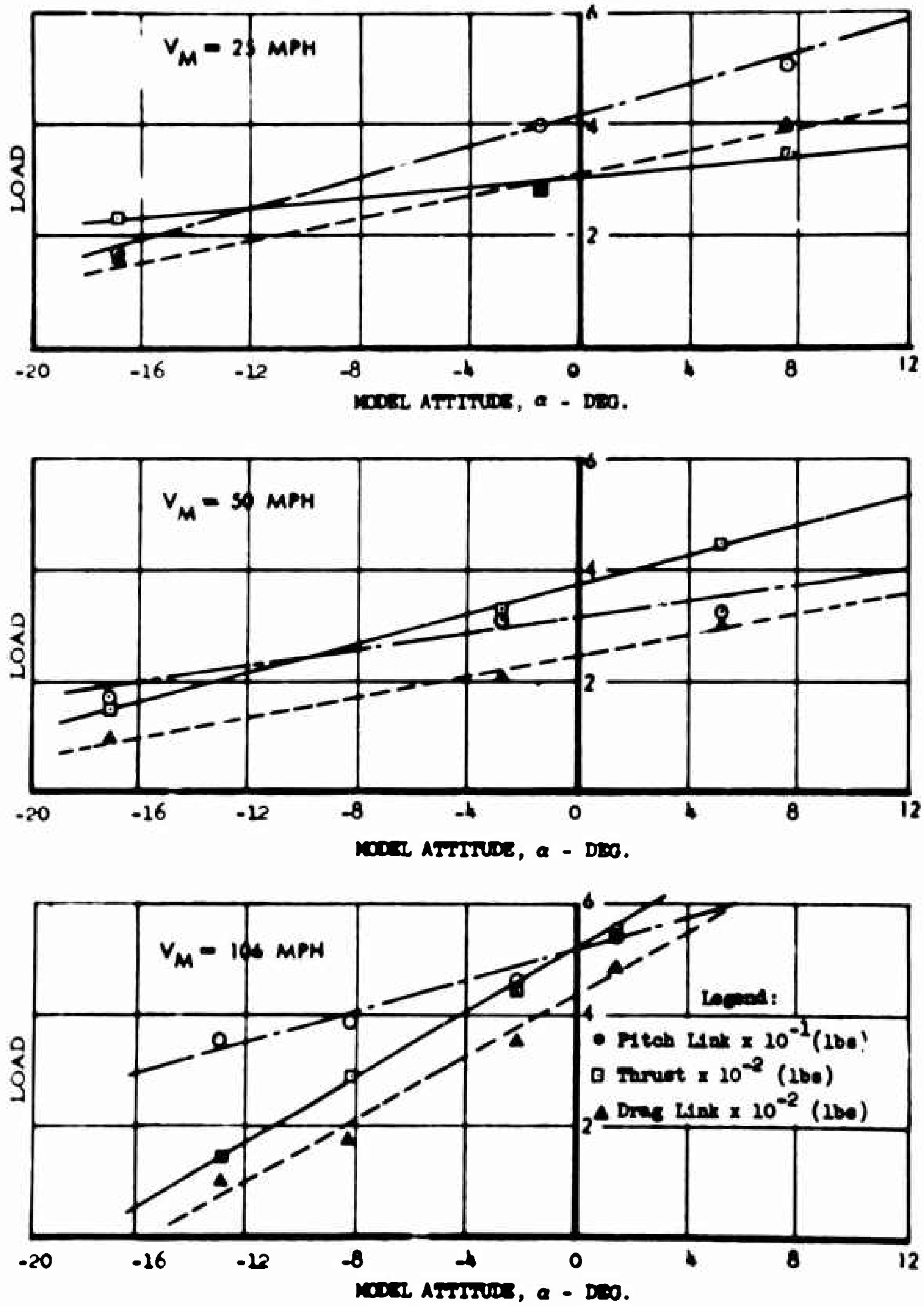


FIGURE 36 THRUST, DRAG LINK AND PITCH LINK LOADS VS. MODEL ATTITUDE - CONFIGURATION B

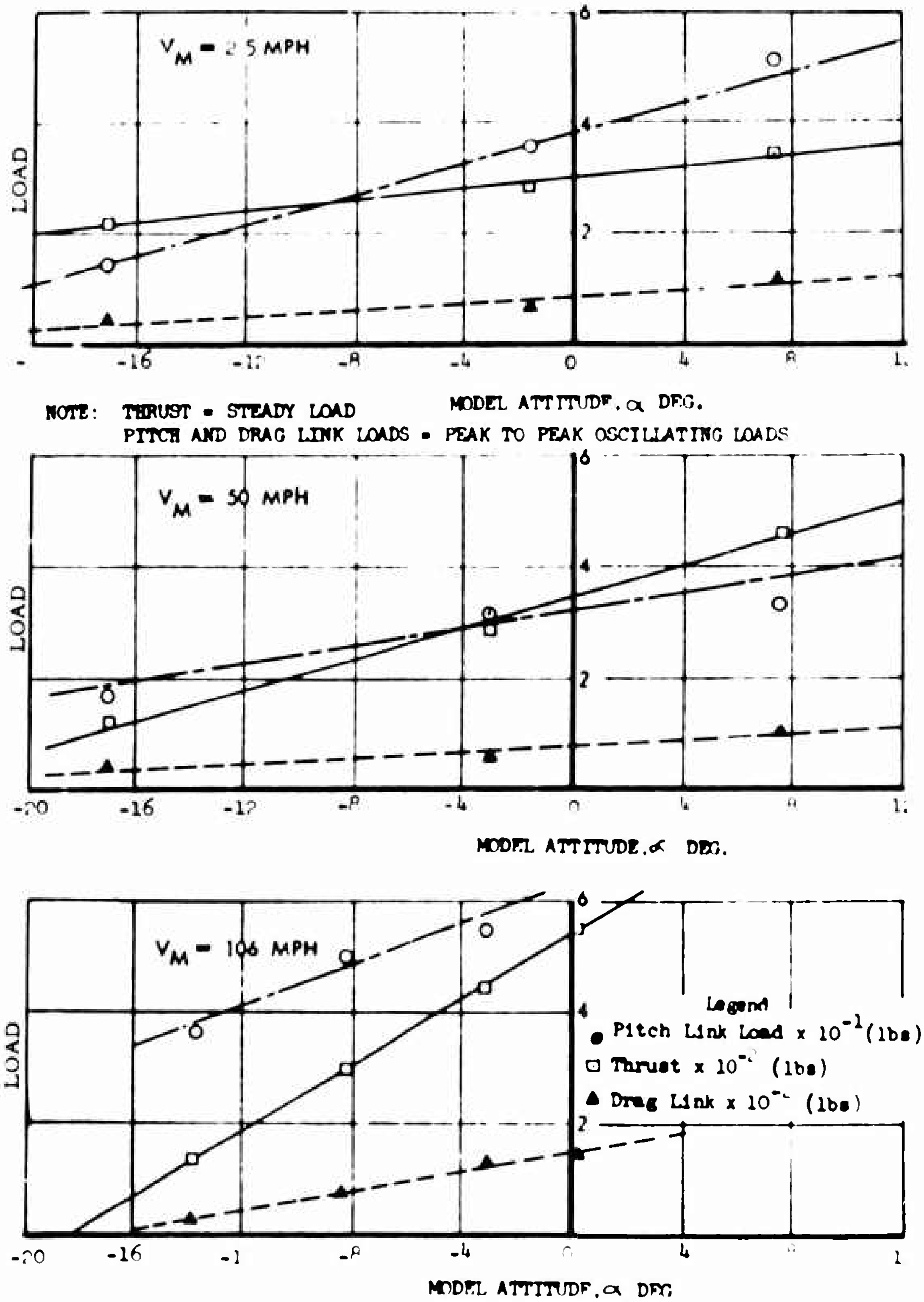


FIGURE 37 THRUST, DRAG LINK AND PITCH LINK LOADS VS. MODEL ATTITUDE - CONFIGURATION C

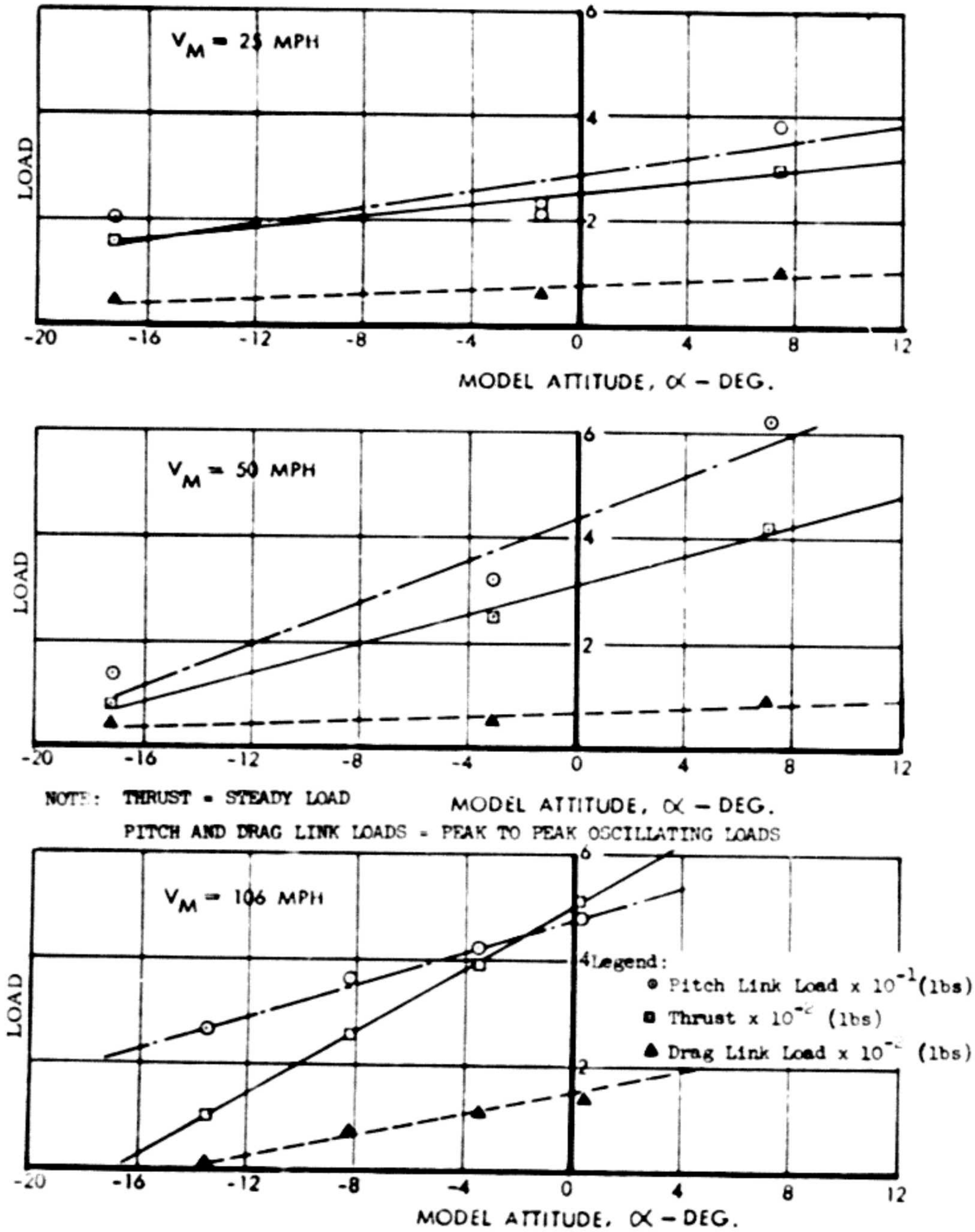


FIGURE 38 THRUST, DRAG LINK AND PITCH LINK LOADS VS. MODEL ATTITUDE - CONFIGURATION D

NOTE: THRUST = STEADY LOAD
PITCH AND DRAG LINK LOADS = PEAK TO PEAK OSCILLATING LOADS

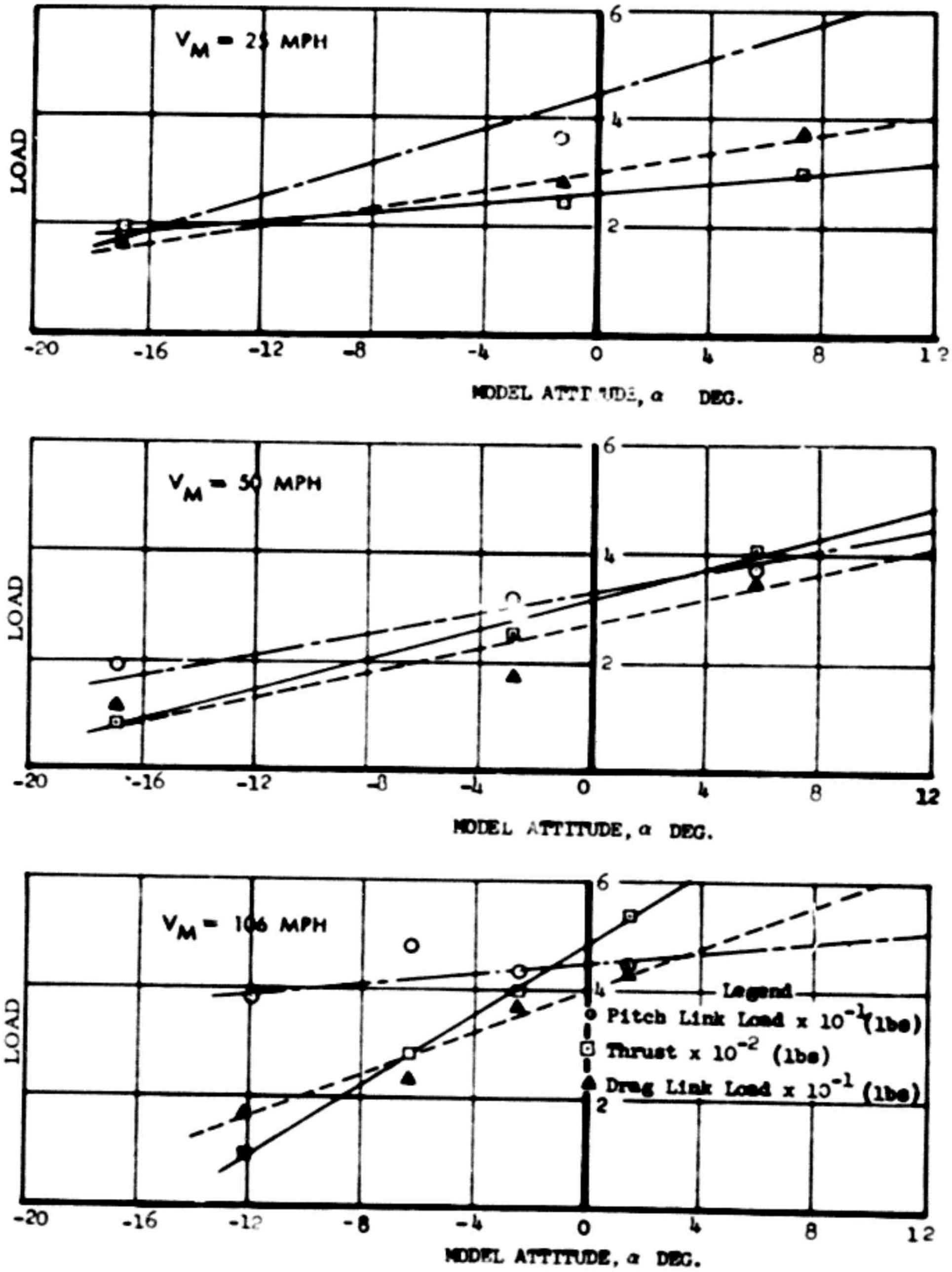


FIGURE 39 THRUST, DRAG LINK AND PITCH LINK LOADS VS. MODEL ATTITUDE - CONFIGURATION E

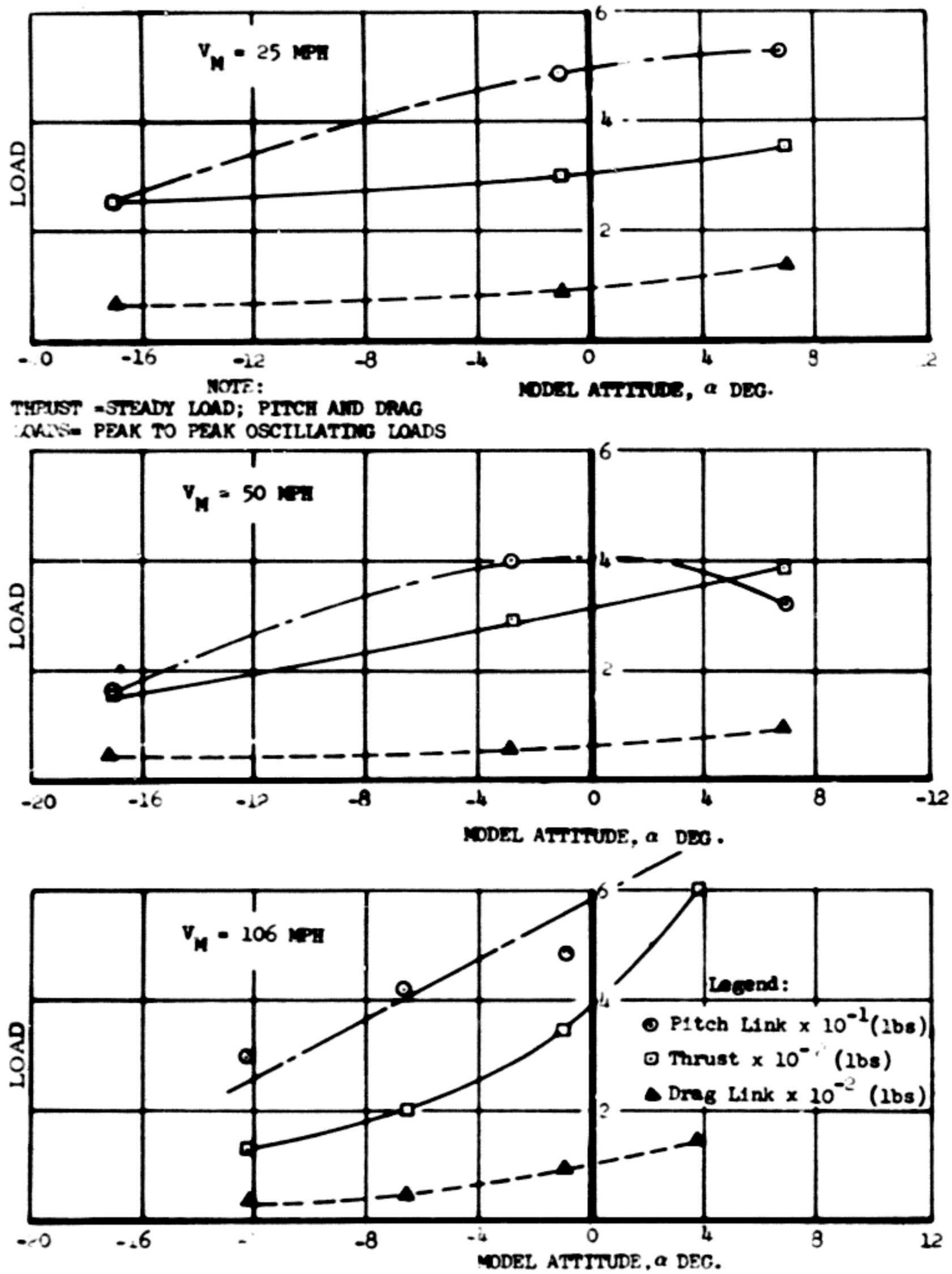


FIGURE 40 THRUST, DRAG LINK AND PITCH LINK LOADS VS. MODEL ATTITUDE - CONFIGURATION F

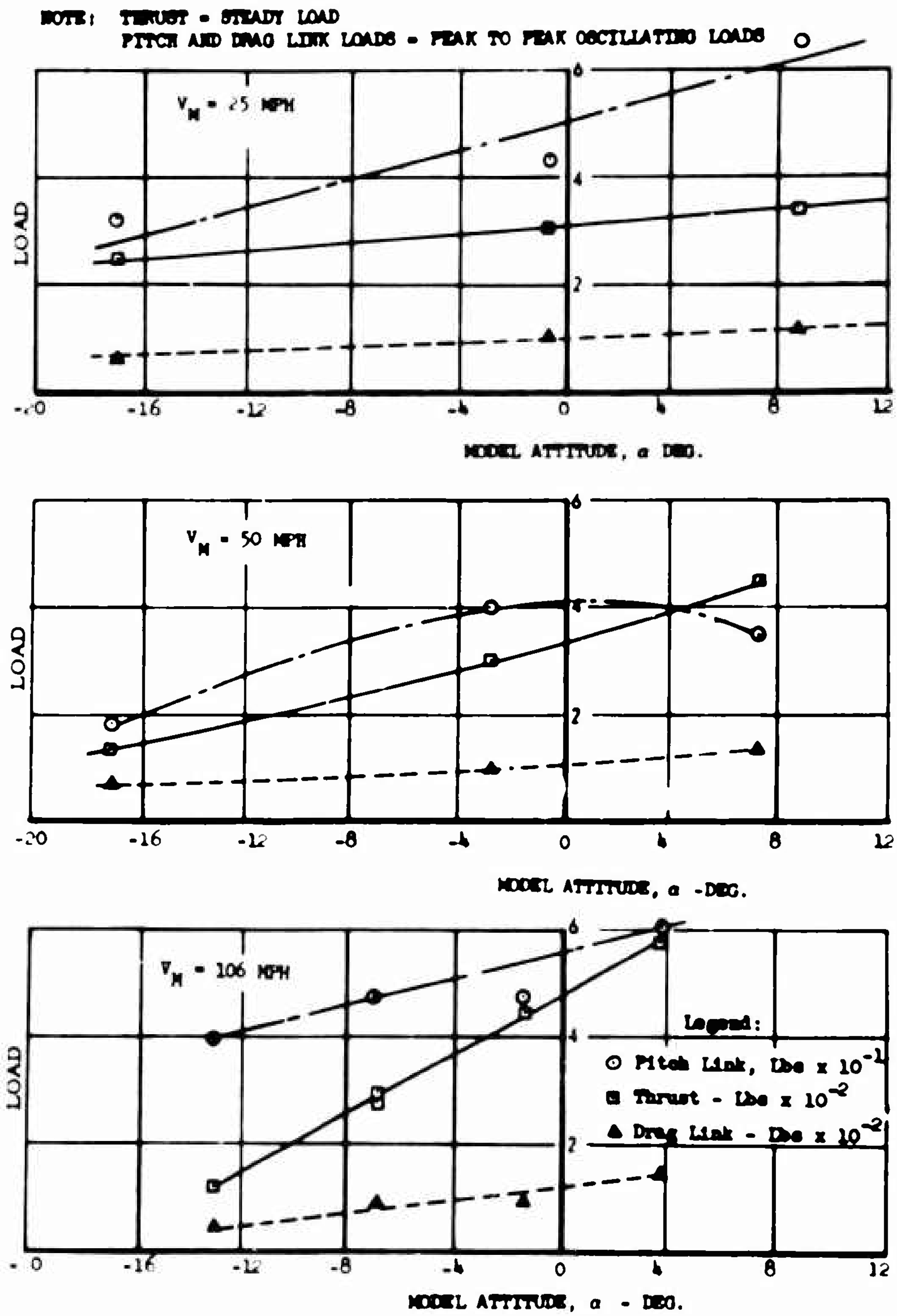
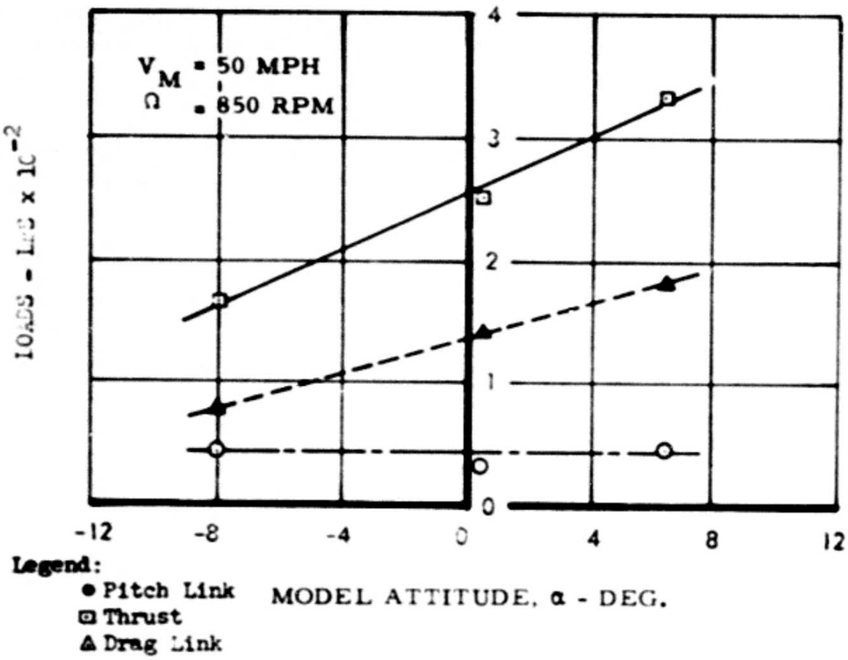


FIGURE 41 THRUST, DRAG LINK AND PITCH LINK LOADS VS. MODEL ATTITUDE - CONFIGURATION G

NOTE: THRUST = STEADY LOAD
PITCH AND DRAG LINK LOADS = PEAK TO PEAK OSCILLATING LOADS



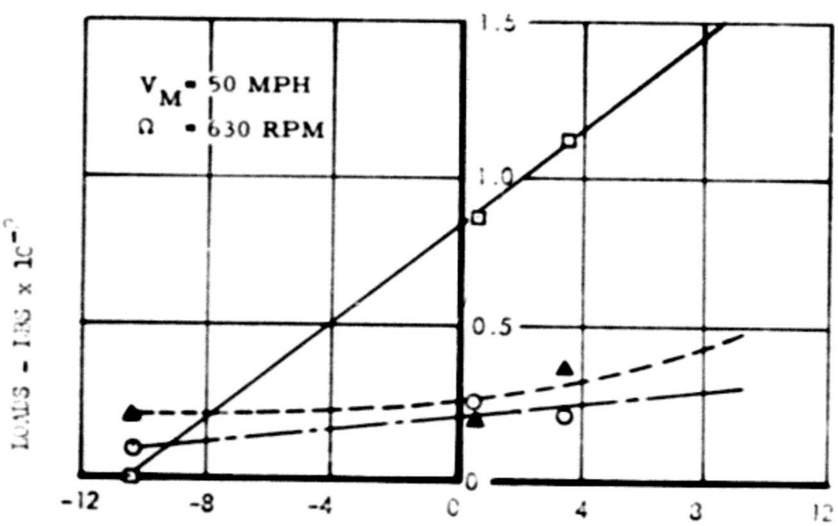


FIGURE 42 THRUST, DRAG LINK AND PITCH LINK LOADS VS. MODEL ATTITUDE - CONFIGURATION H

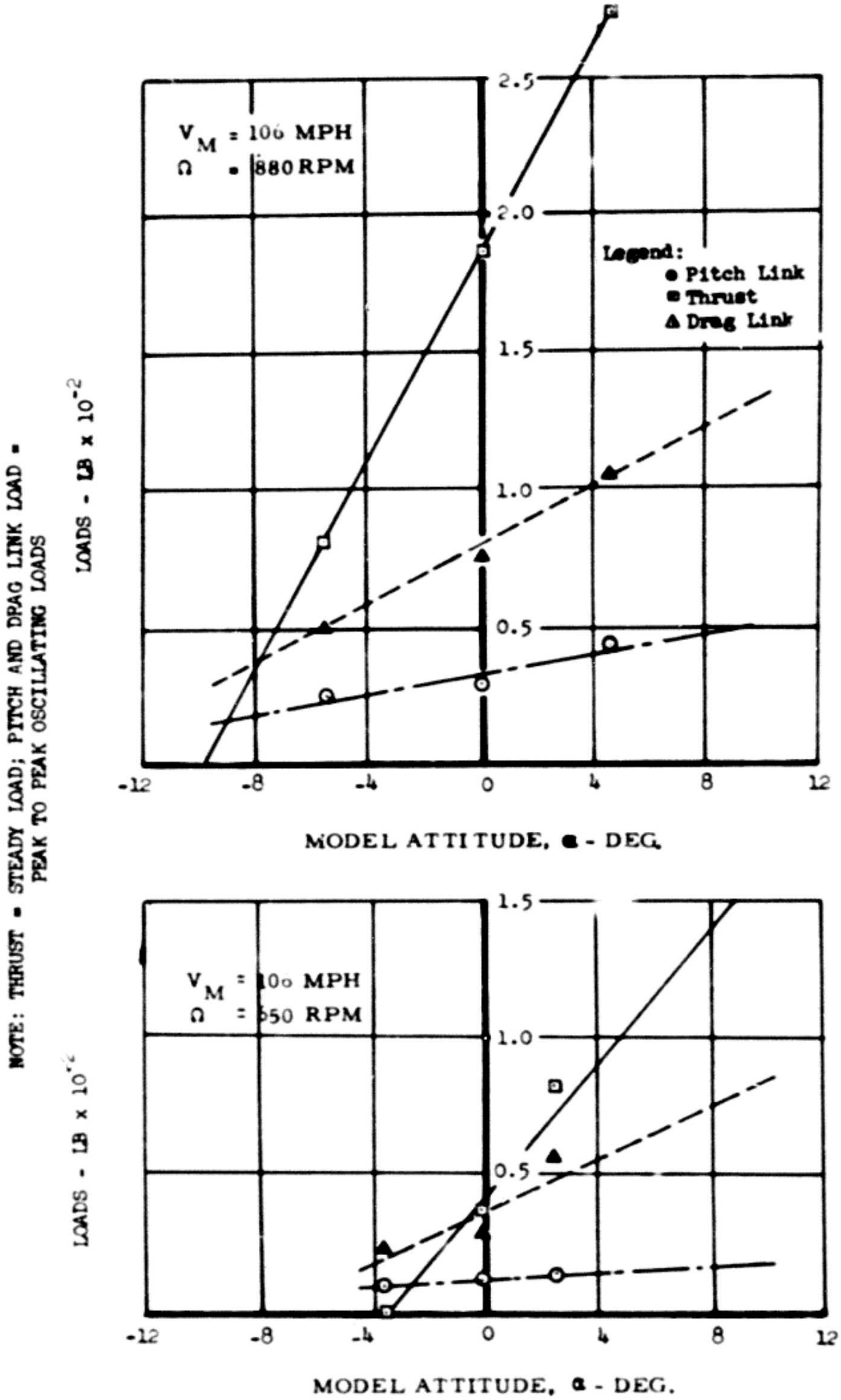


FIGURE 43 THRUST, DRAG LINK AND PITCH LINK LOADS VS. MODEL ATTITUDE - CONFIGURATION H

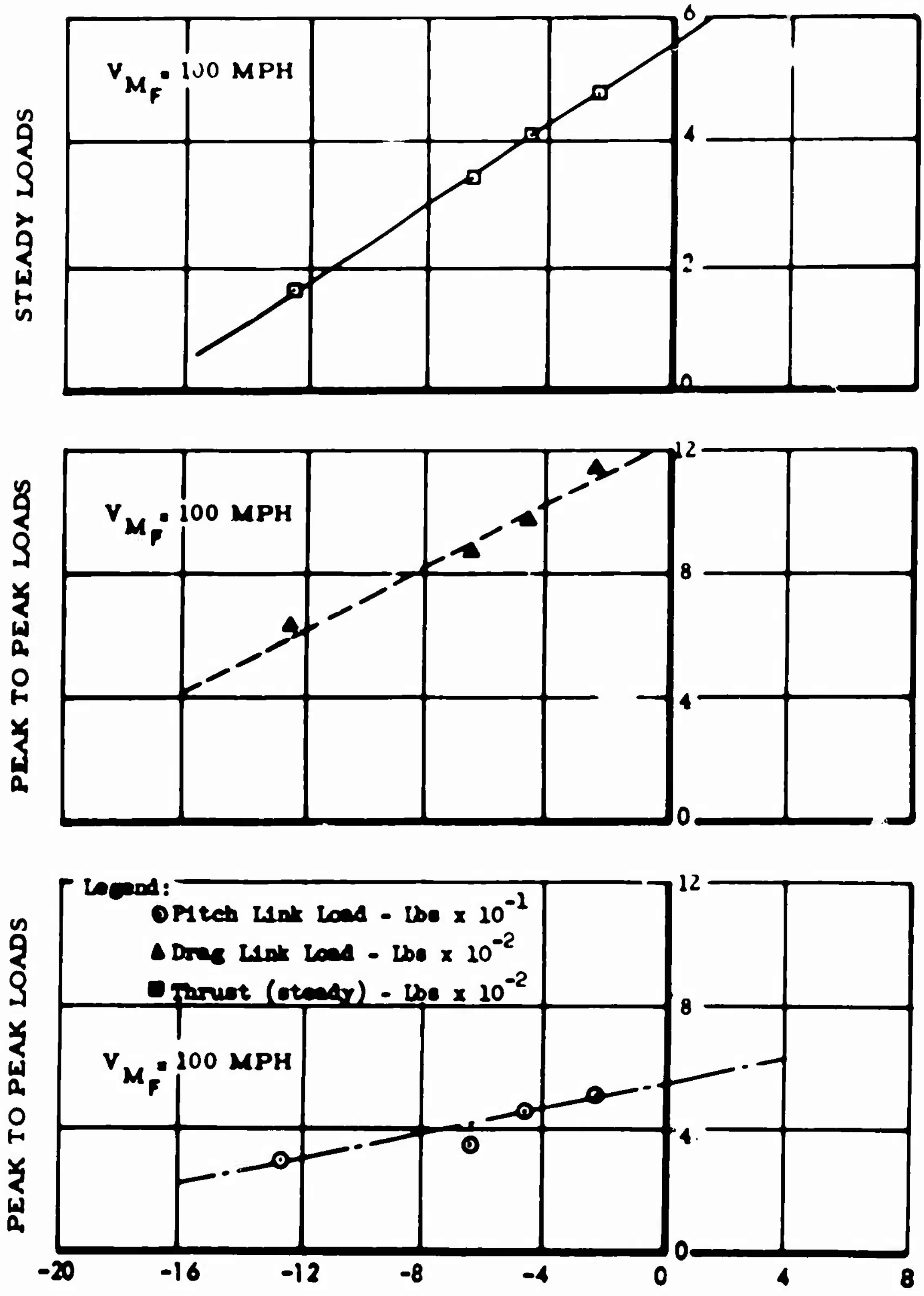


FIGURE 44 THRUST, DRAG LINK AND PITCH LINK LOADS VS. MODEL ATTITUDE - CONFIGURATION K

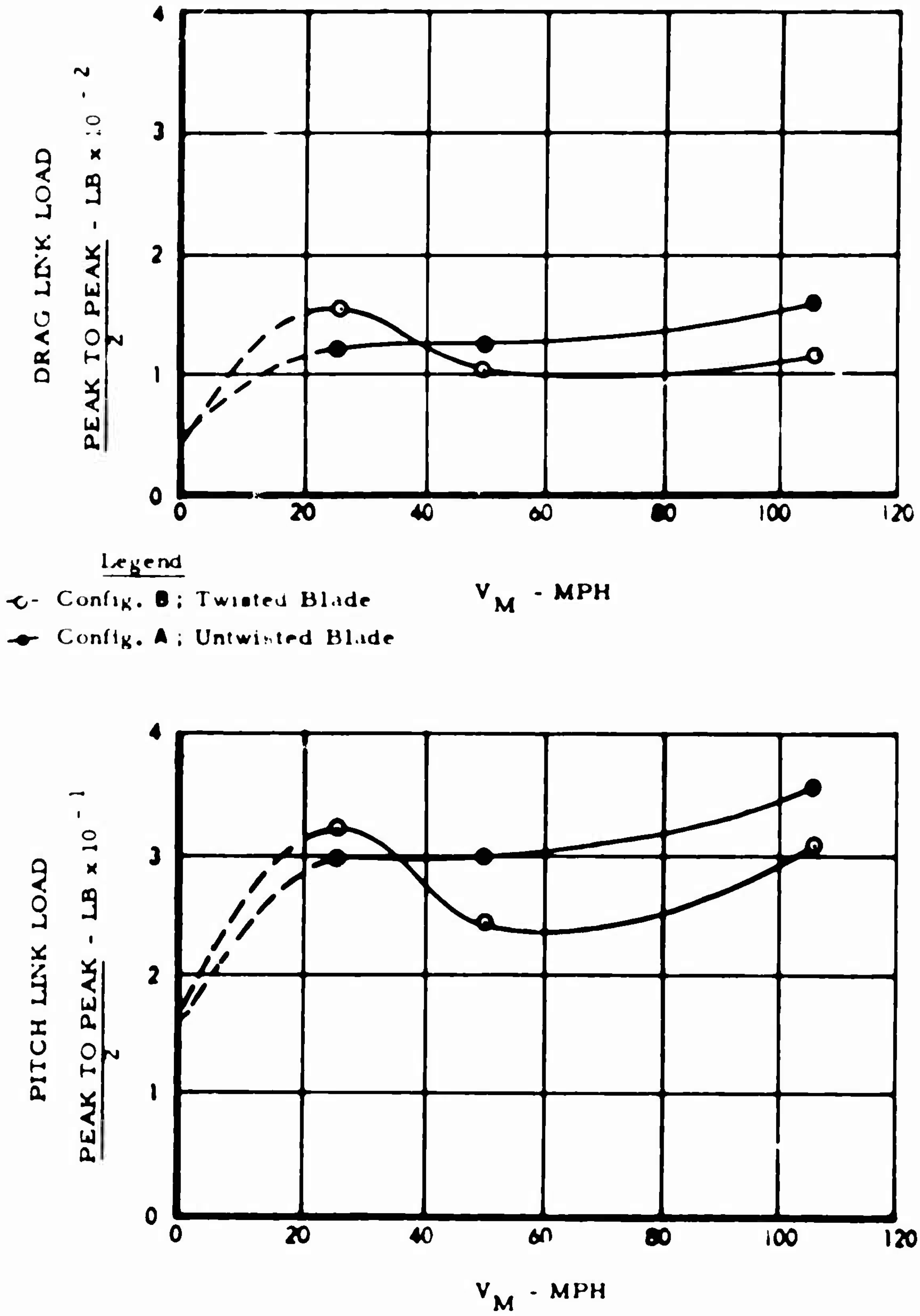


FIGURE 45 COMPARISON OF DRAG AND PITCH LINK LOADS BETWEEN CONFIGURATIONS A AND B

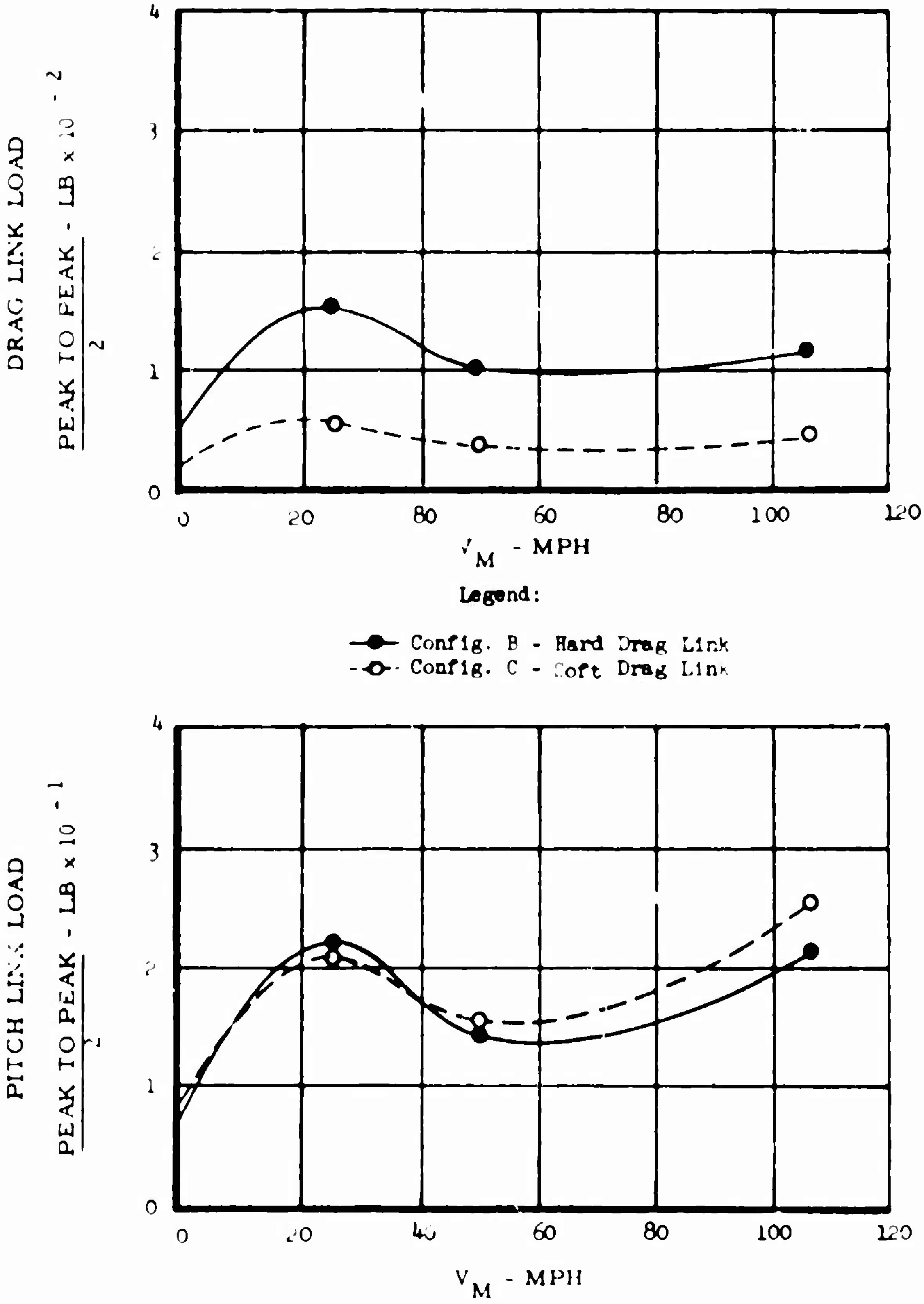
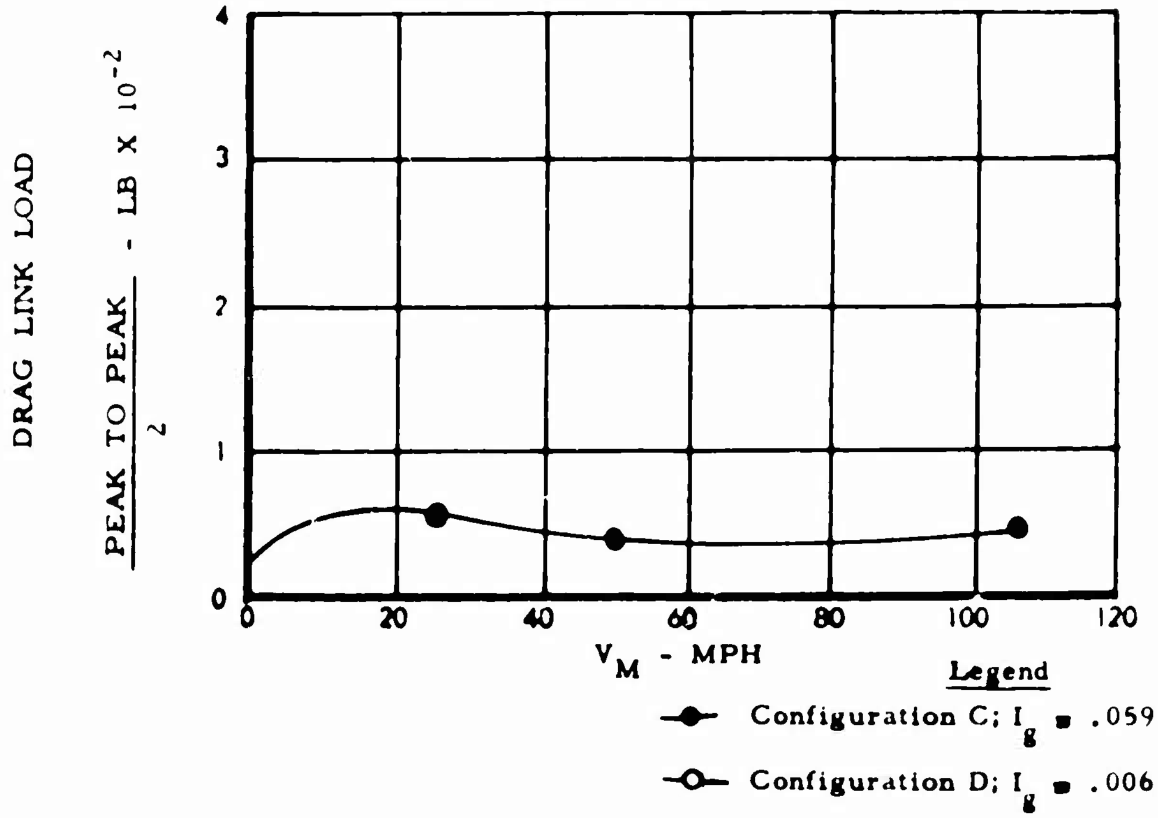


FIGURE 46 COMPARISON OF DRAG AND PITCH LINK LOADS BETWEEN CONFIGURATIONS B AND C



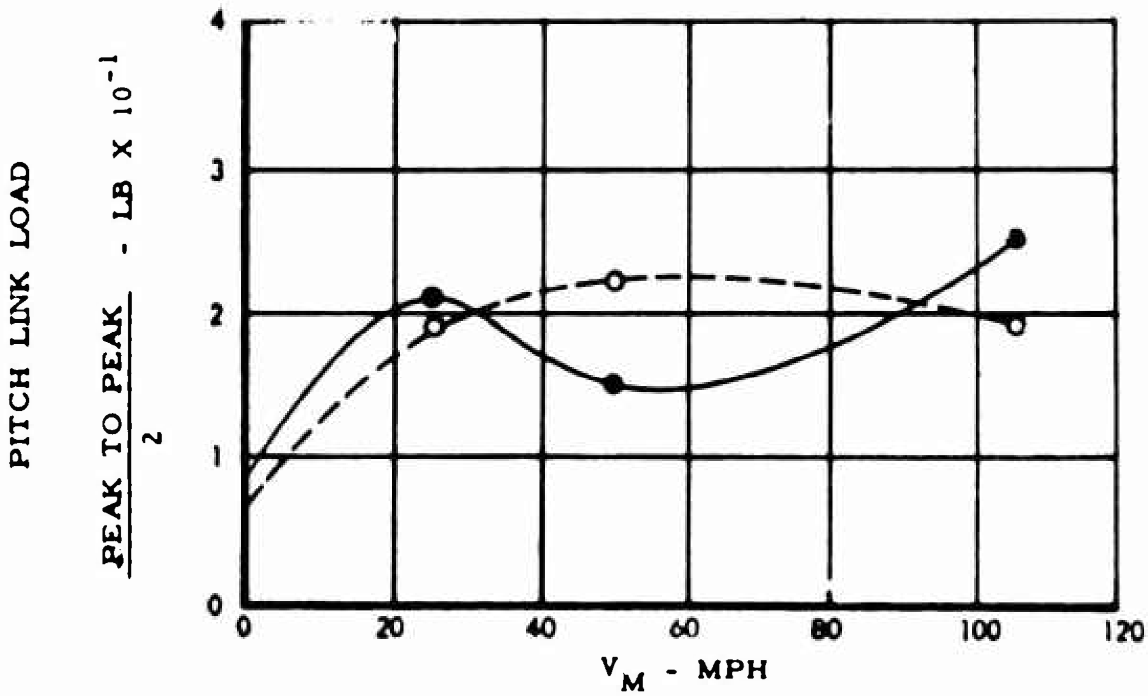
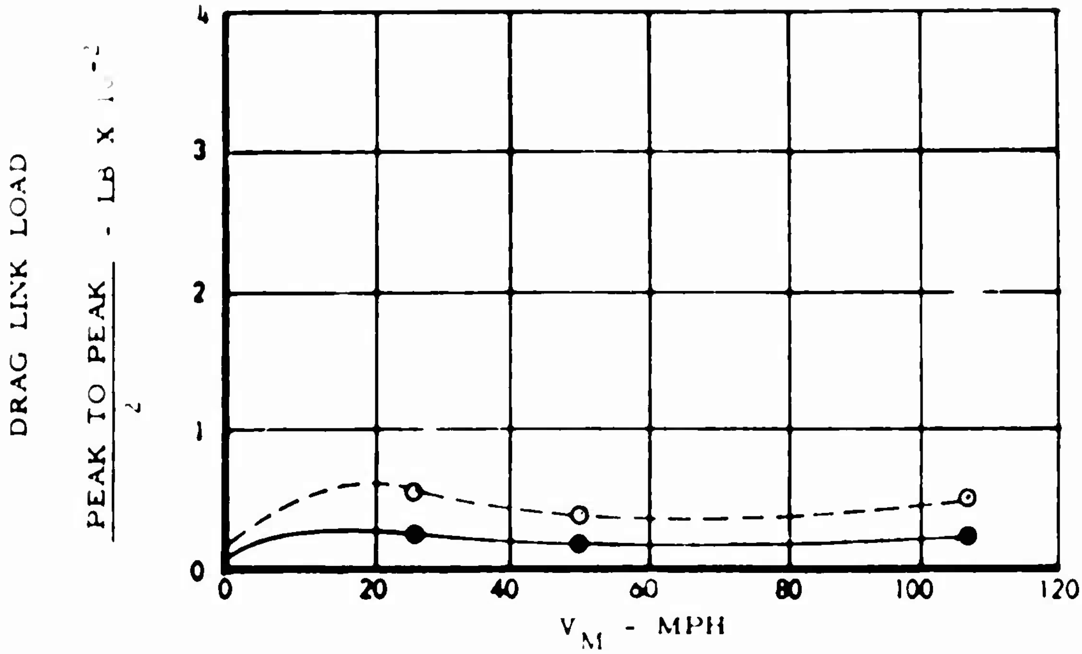


FIGURE 47 COMPARISON OF DRAG AND PITCH LINK LOADS BETWEEN CONFIGURATIONS C AND D



Legend

Configuration D; twisted blades

Configuration E; untwisted glass

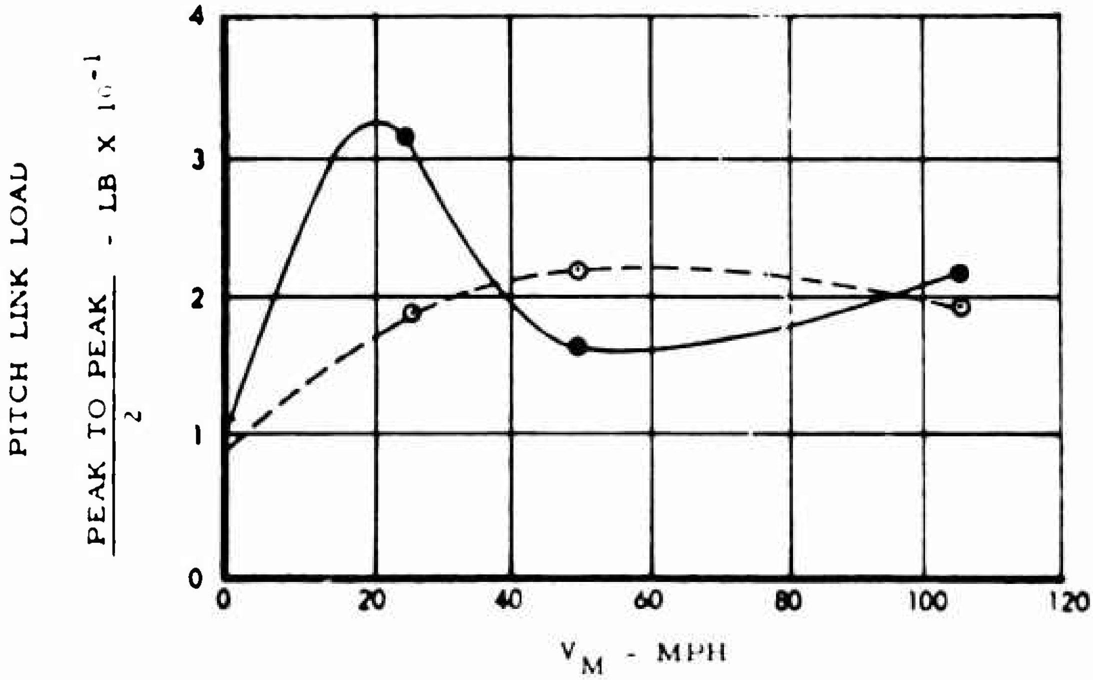
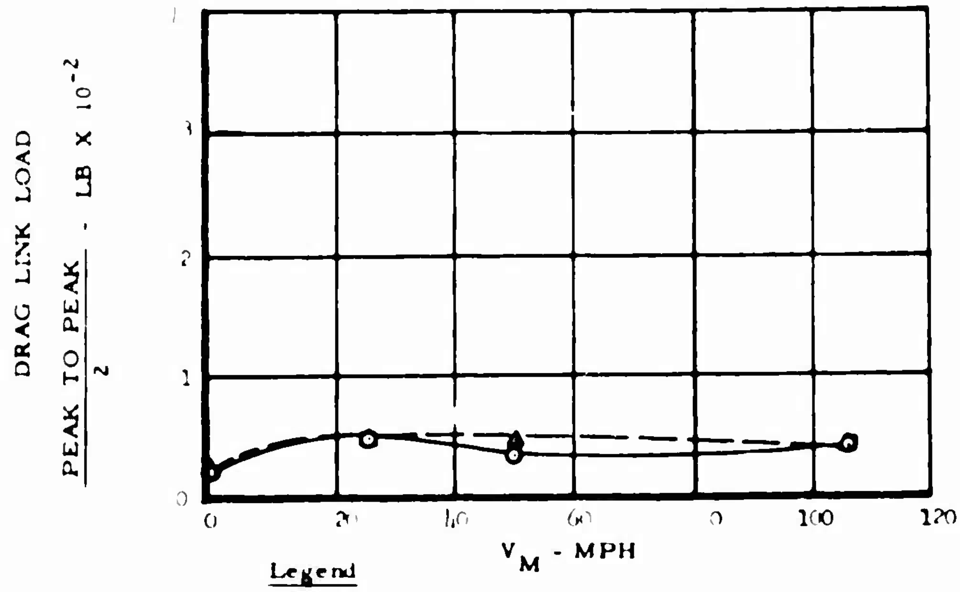


FIGURE 48 COMPARISON OF DRAG AND PITCH LINK LOADS BETWEEN CONFIGURATIONS D AND E



Legend

- ▢ Configuration D; hard hub, λ = 1.5
- ⊙ Configuration F; soft hub, λ = 1.5
- △ Configuration G; hard hub, λ = 3.0

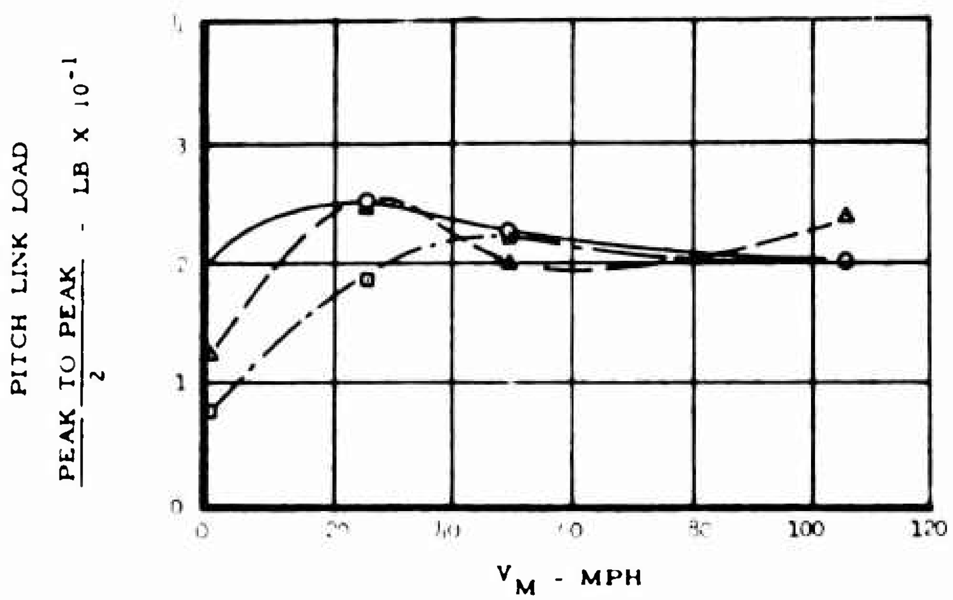


FIGURE 49 COMPARISON OF DRAG AND PITCH LINK LOADS BETWEEN CONFIGURATIONS D, F AND G

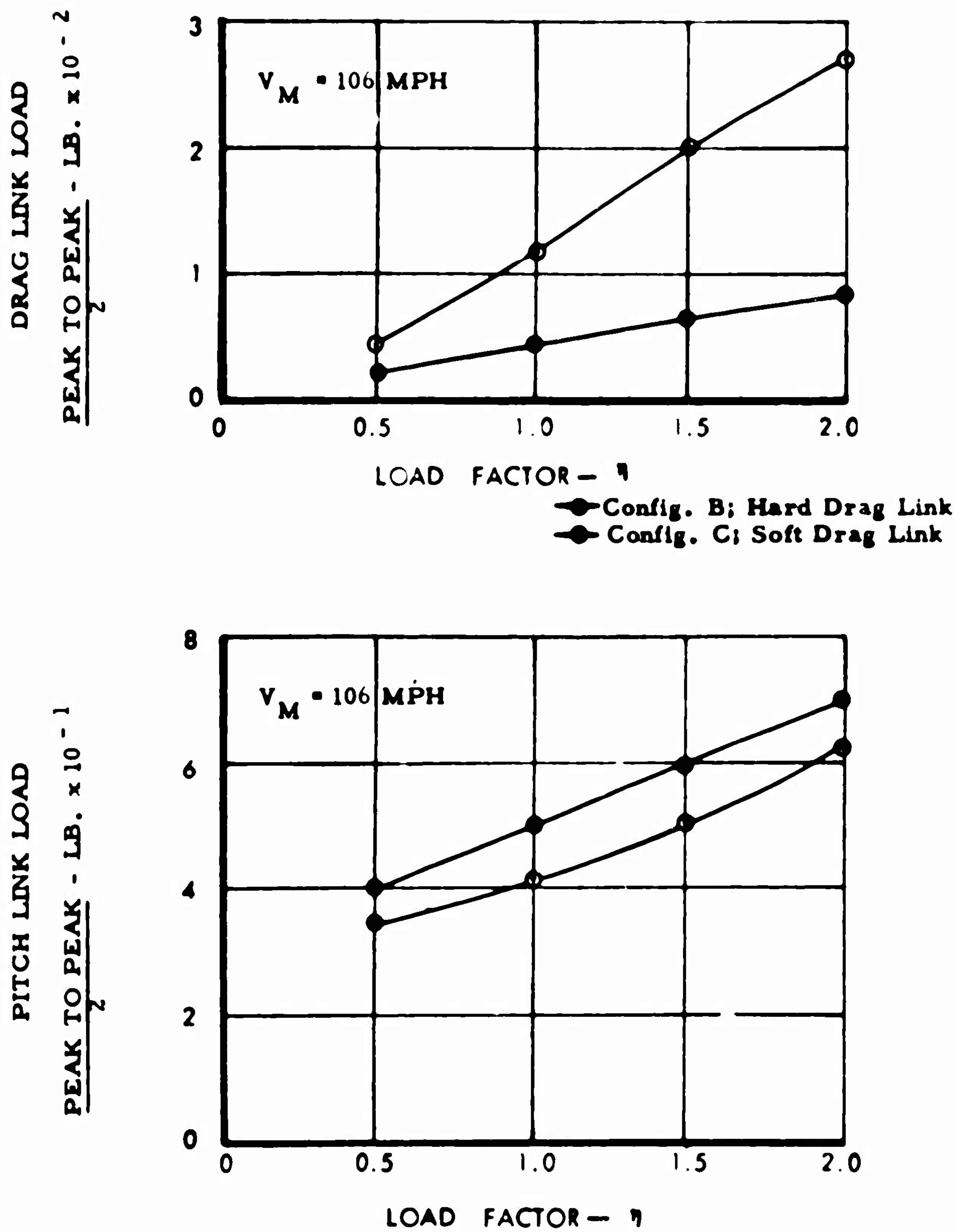


FIGURE 50 COMPARISON OF DRAG AND PITCH LINK LOADS BETWEEN CONFIGURATIONS B AND C

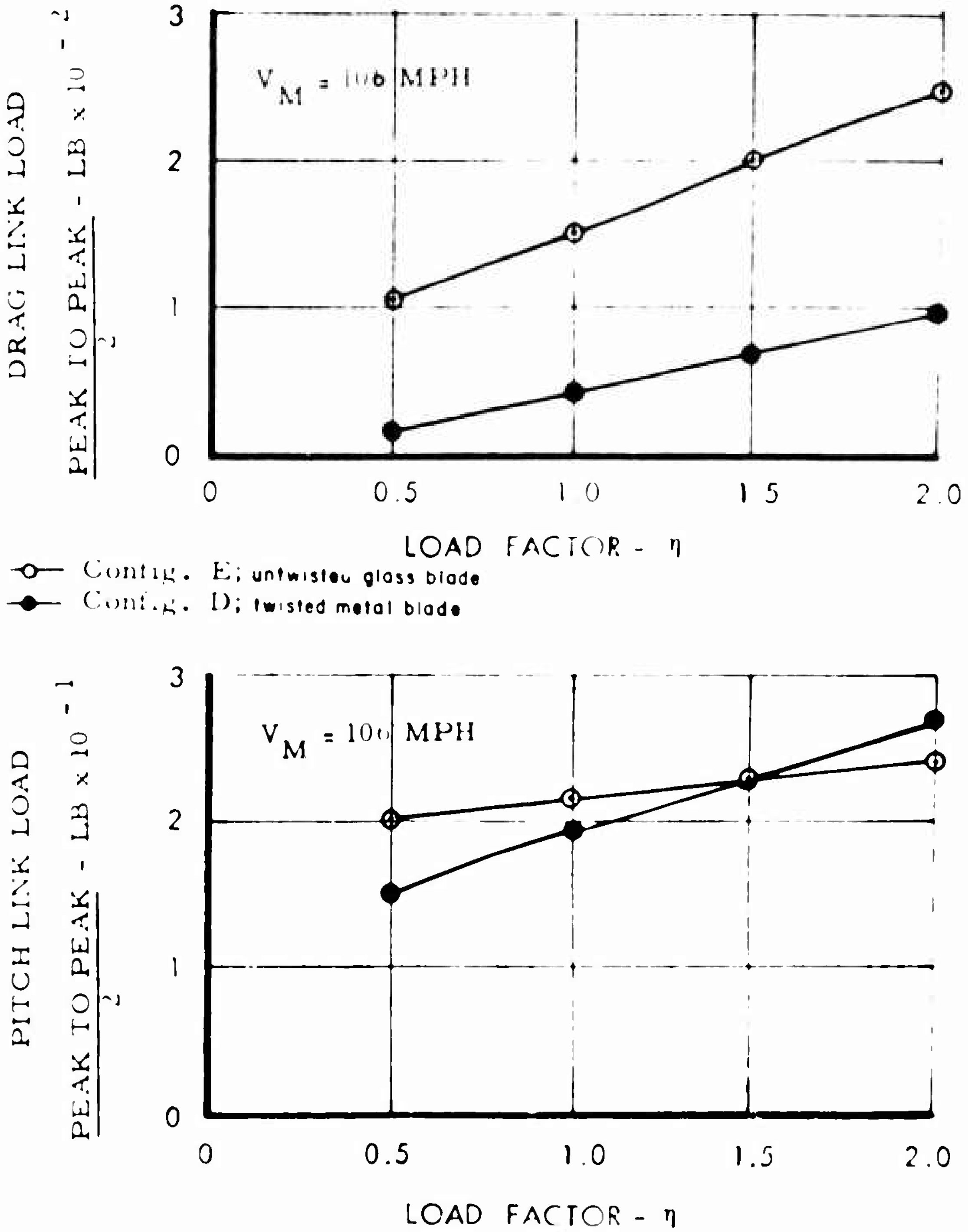


FIGURE 51 COMPARISON OF DRAG AND PITCH LINK LOADS BETWEEN CONFIGURATIONS D AND E

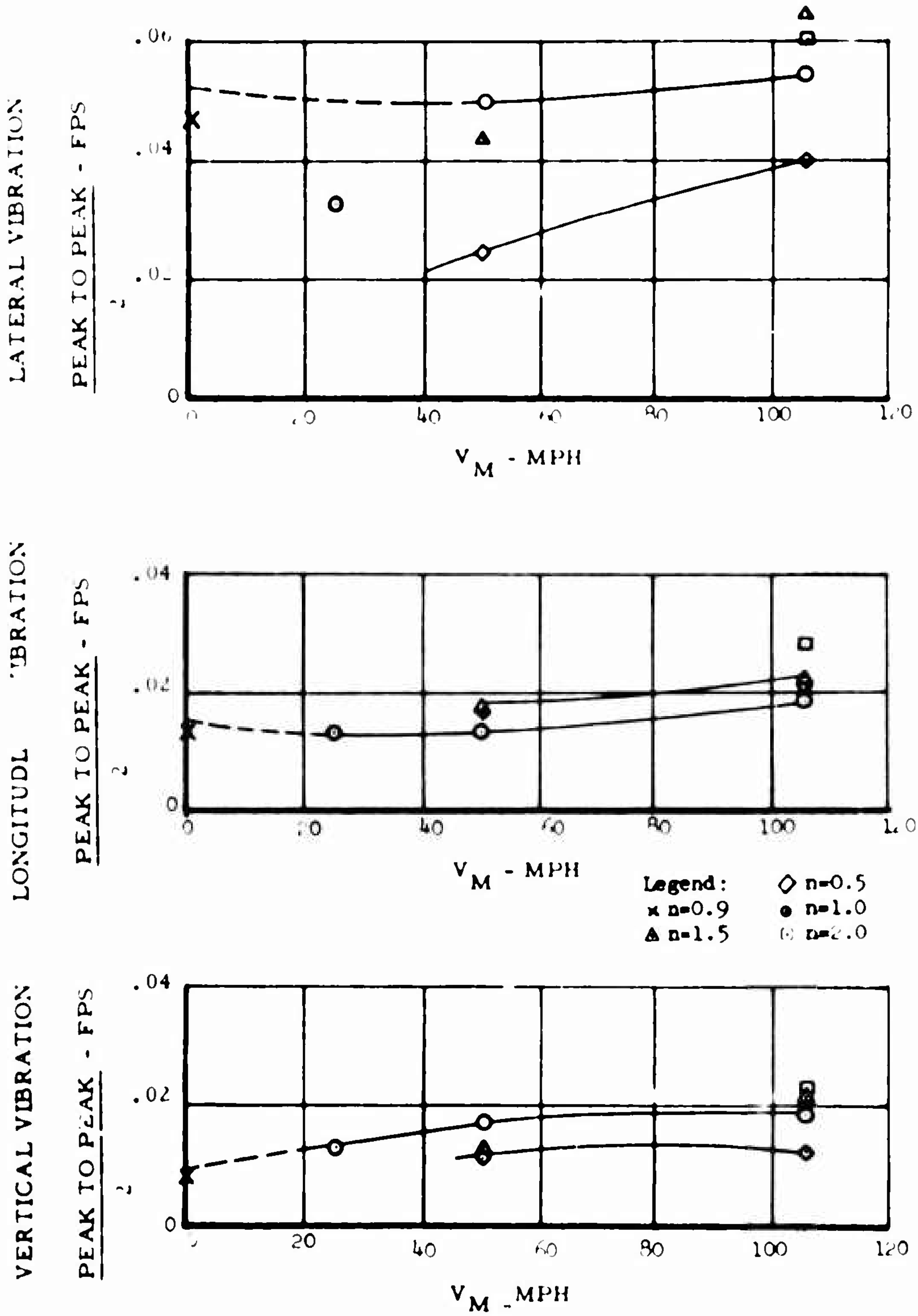


FIGURE 52 LATERAL, LONGITUDINAL AND VERTICAL VIBRATION VS VELOCITY FOR CONFIGURATION A

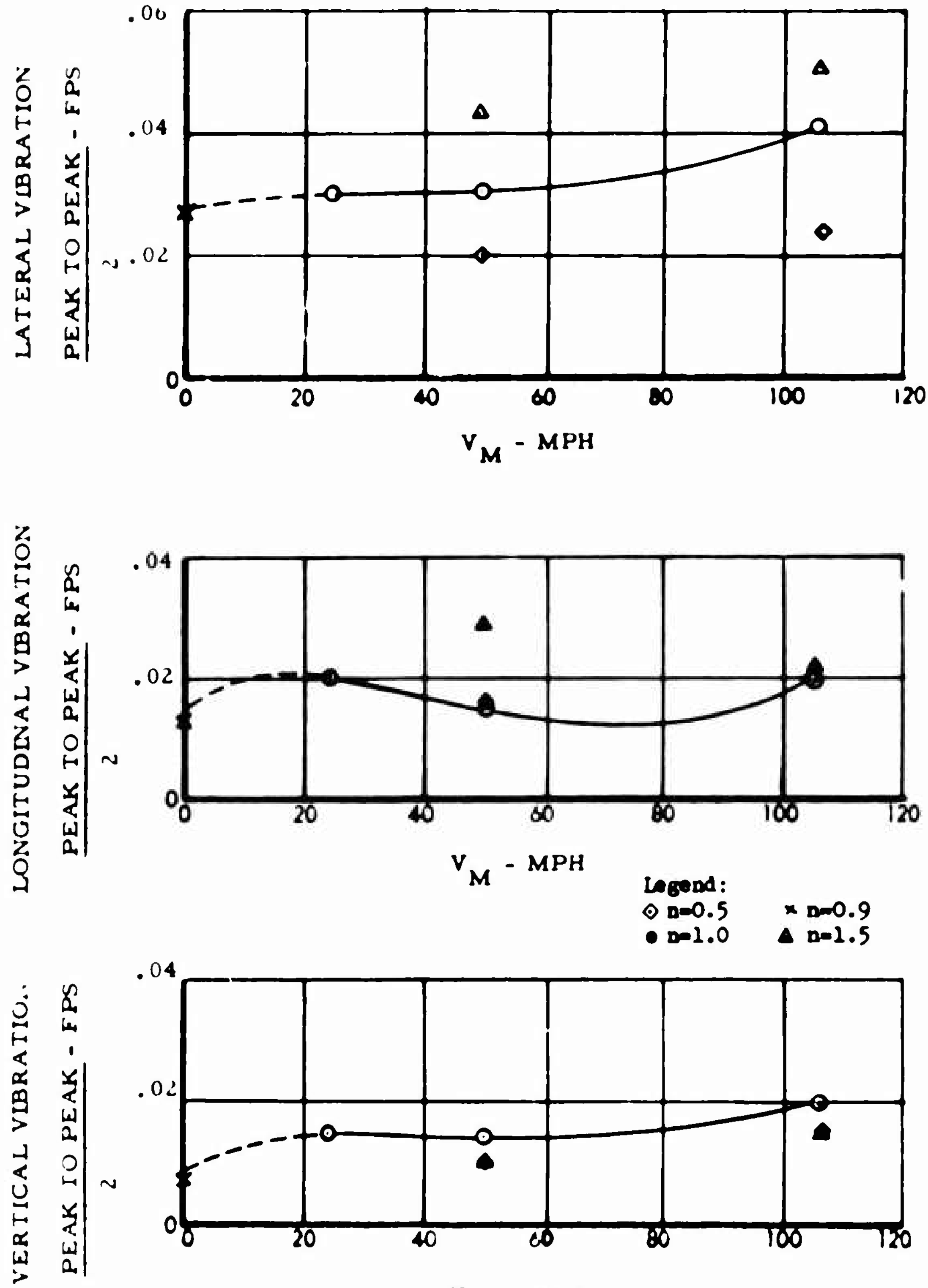


FIGURE 53 LATERAL, LONGITUDINAL AND VERTICAL VIBRATION VS VELOCITY FOR CONFIGURATION B

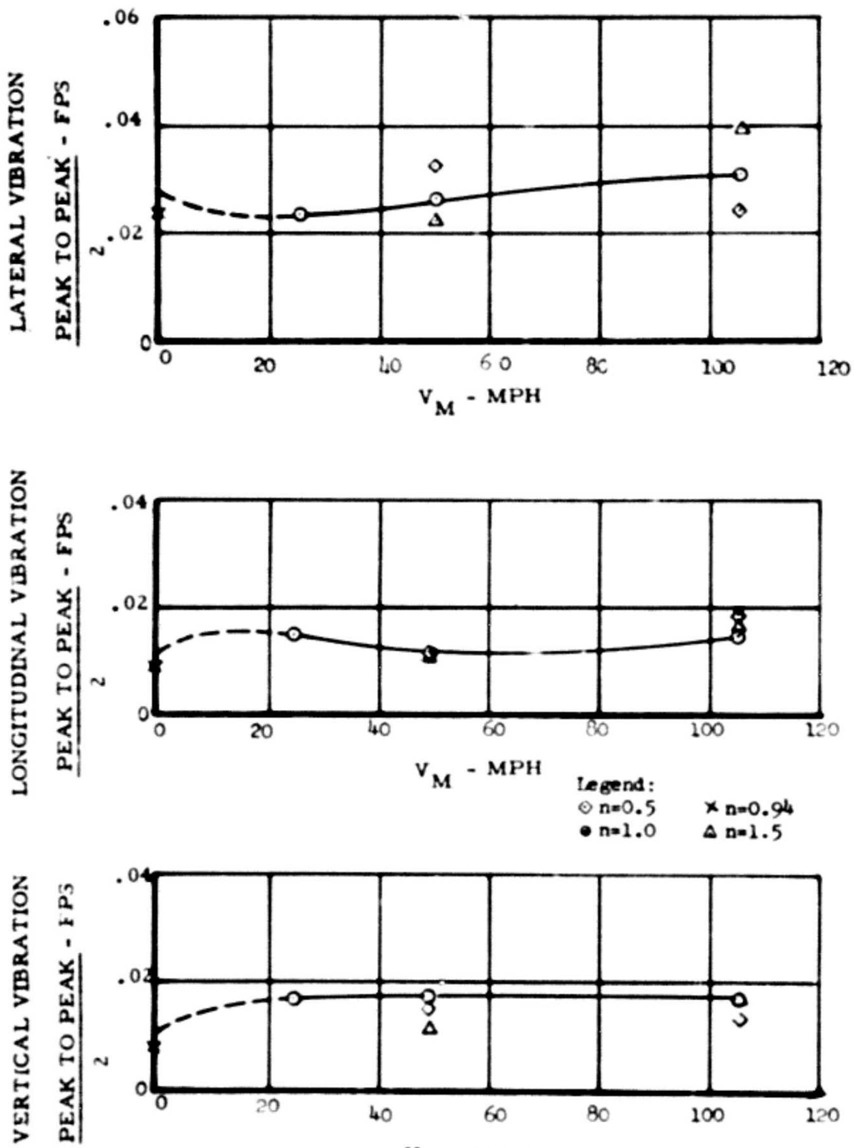


FIGURE 54 LATERAL, LONGITUDINAL AND VERTICAL VIBRATION VS VELOCITY FOR CONFIGURATION C

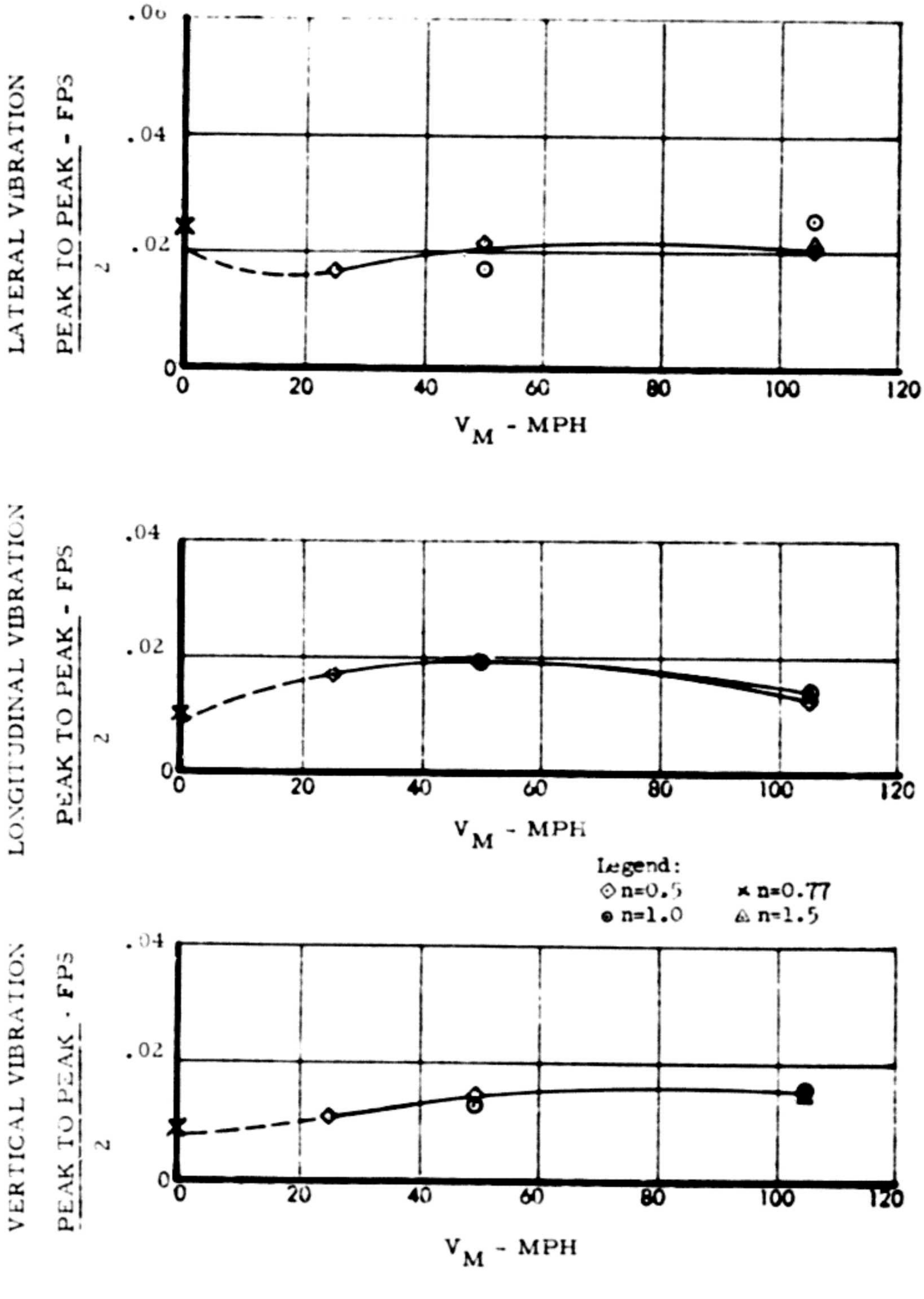


FIGURE 55 LATERAL, LONGITUDINAL, AND VERTICAL VIBRATION VS VELOCITY FOR CONFIGURATION D

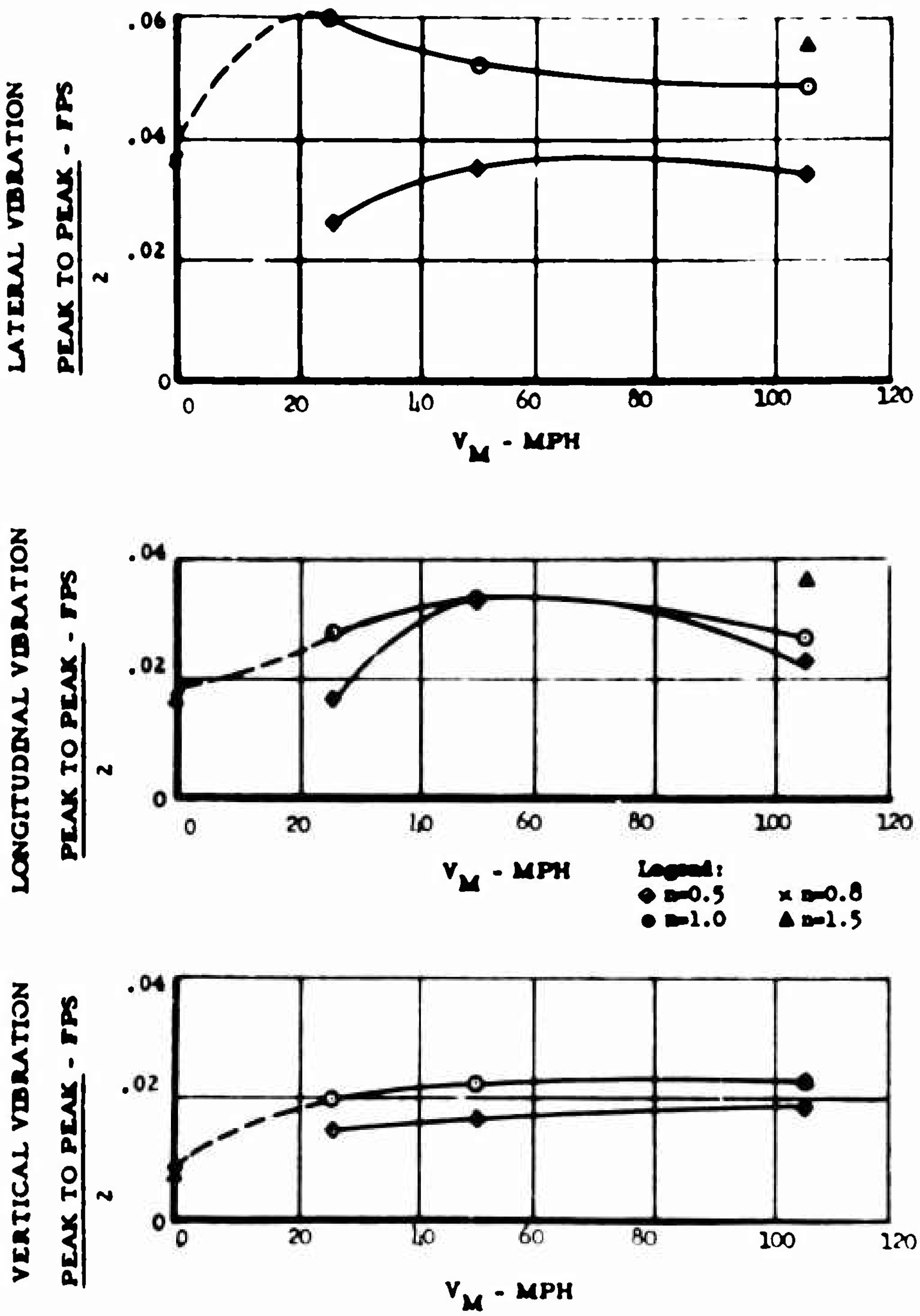


FIGURE 56 LATERAL, LONGITUDINAL, AND VERTICAL VIBRATION VS VELOCITY FOR CONFIGURATION E

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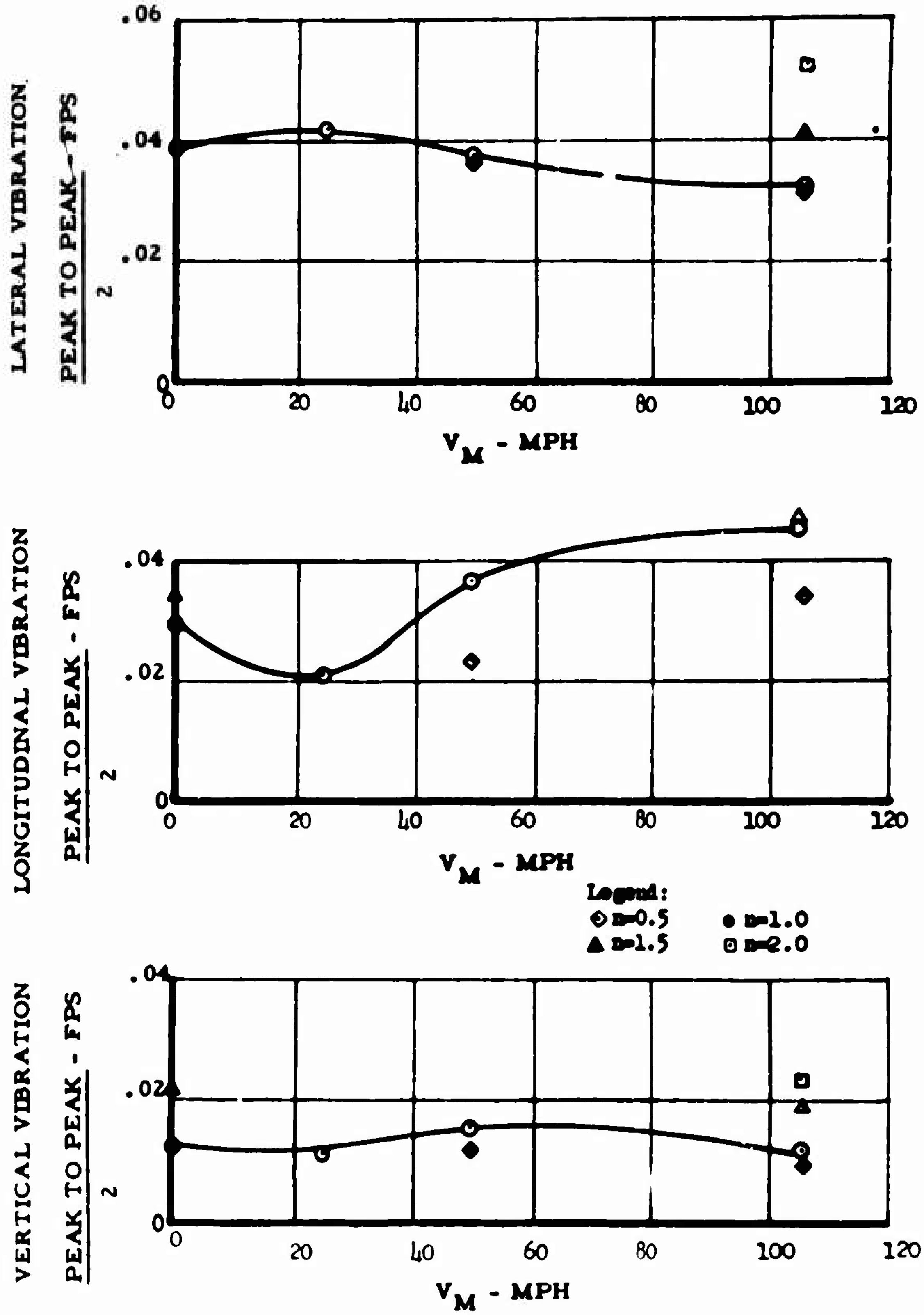

FIGURE 57 LATERAL, LONGITUDINAL, AND VERTICAL VIBRATION VS VELOCITY FOR CONFIGURATION F

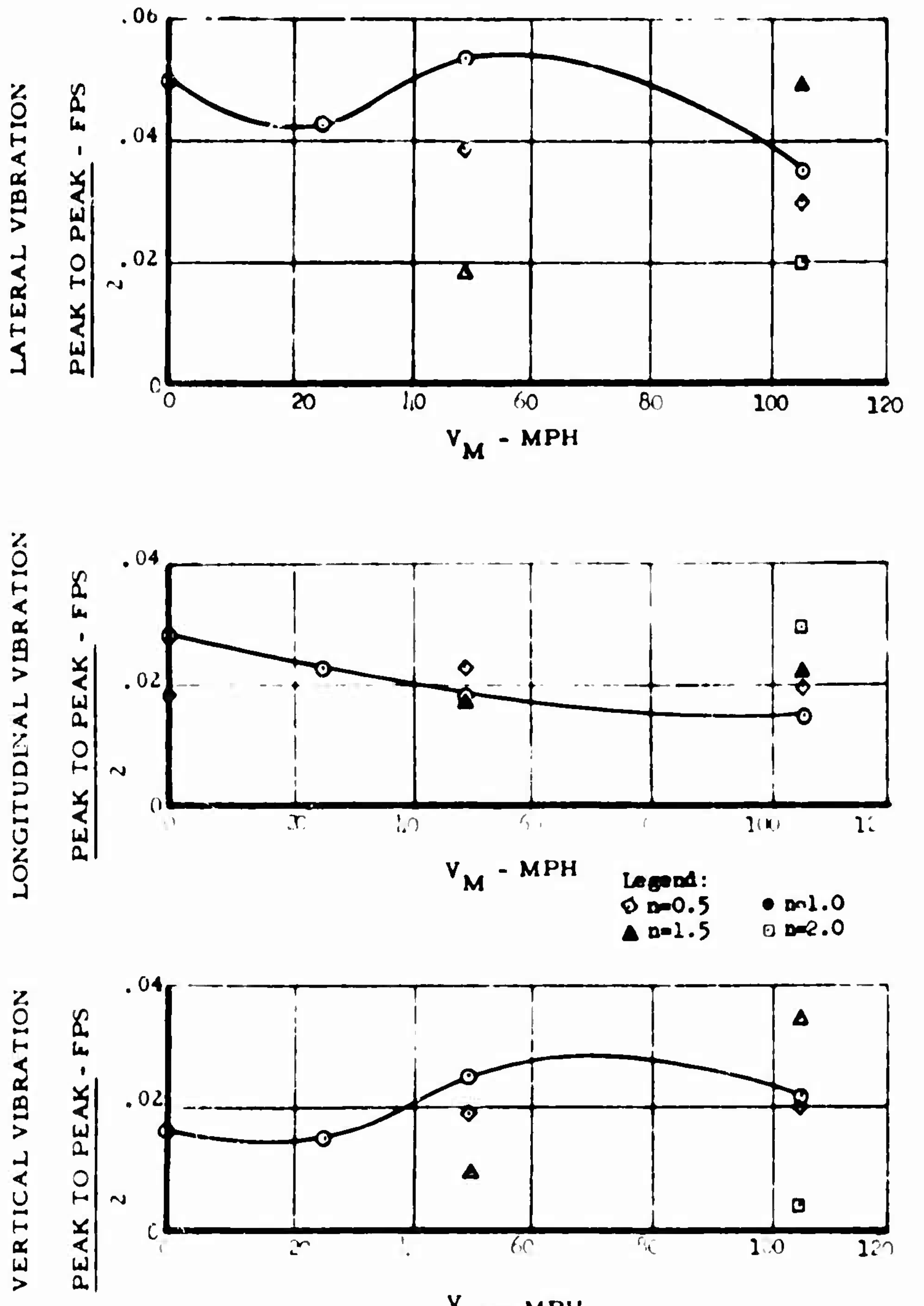

FIGURE 58 LATERAL, LONGITUDINAL, AND VERTICAL VIBRATION VS VELOCITY FOR CONFIGURATION G

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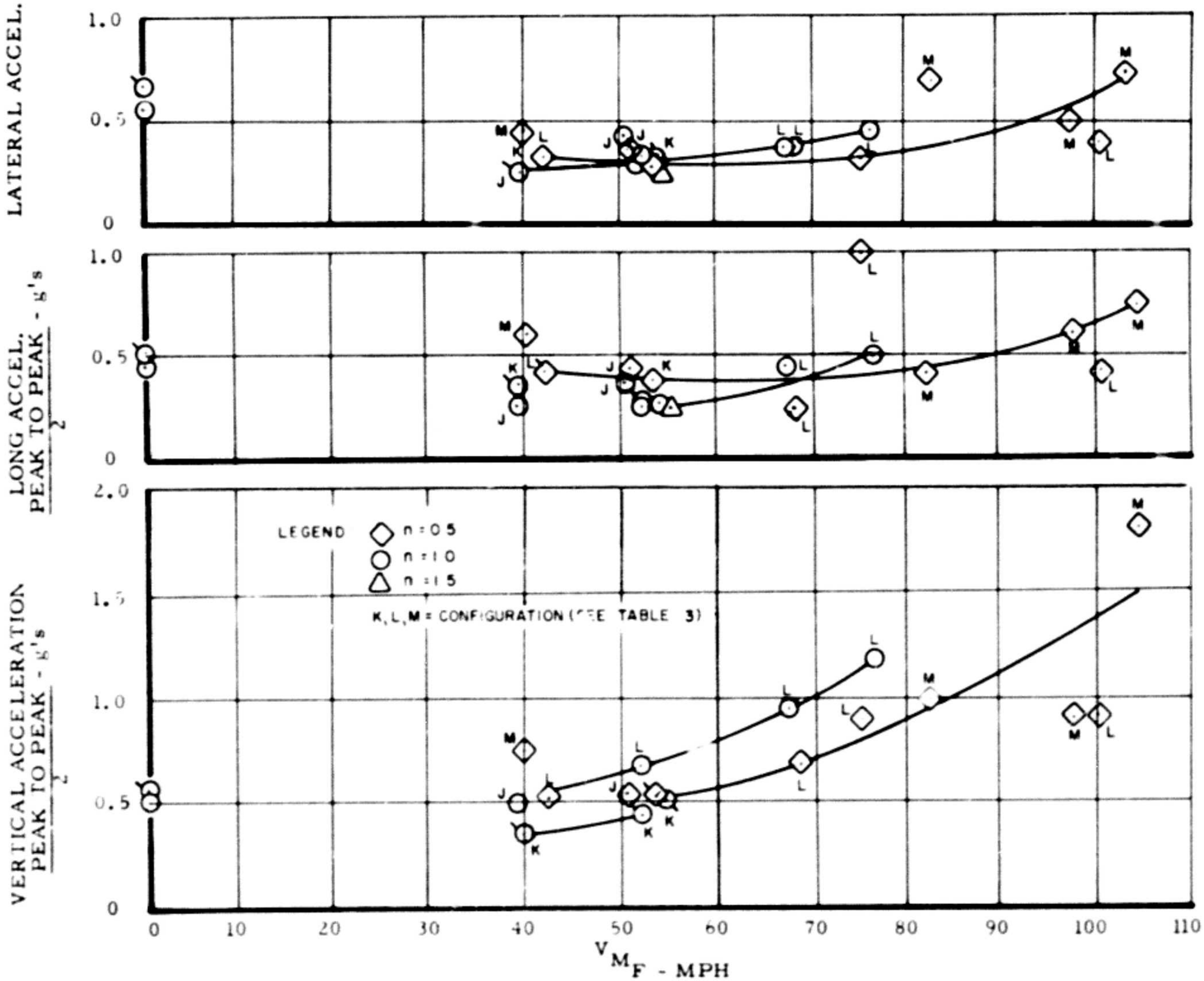

FIGURE 59 VIBRATION LEVELS VS VELOCITY OF MODEL IN FREON

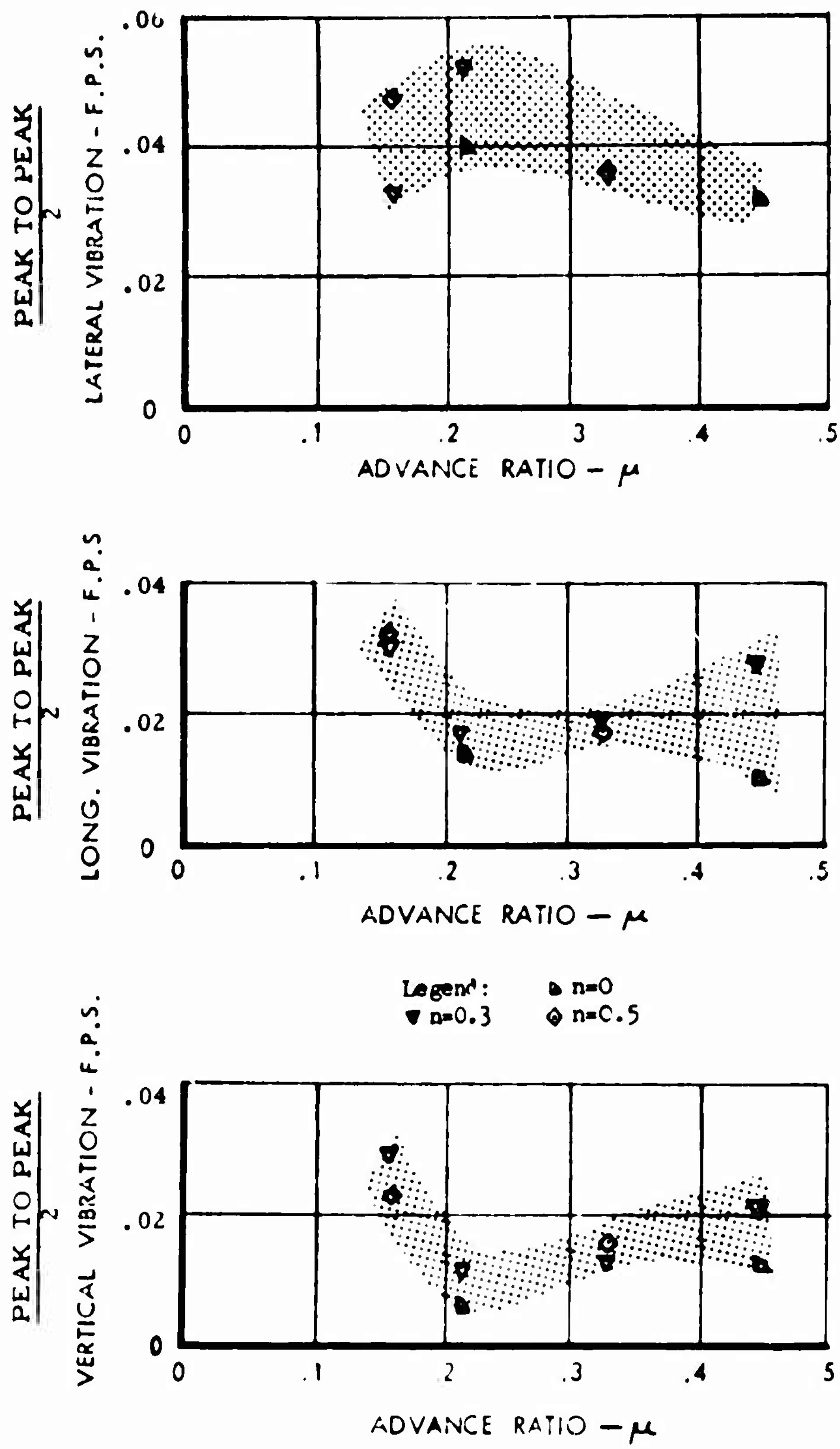

FIGURE 60 LATERAL, LONGITUDINAL AND VERTICAL VIBRATION VS ADVANCE RATIO FOR CONFIGURATION H

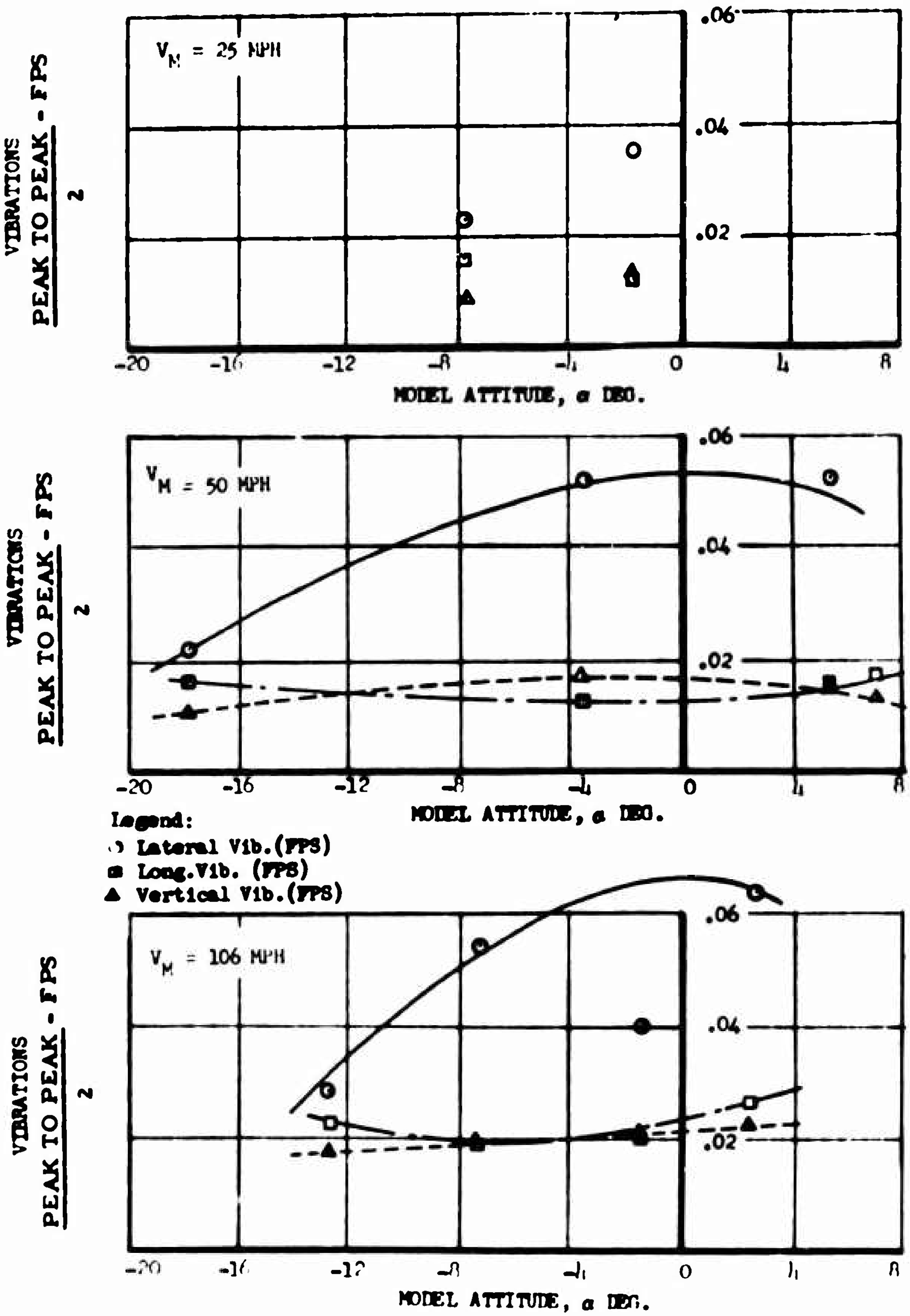

FIGURE 61 LATERAL, LONGITUDINAL, AND VERTICAL VIBRATIONS VS MODEL ATTITUDE FOR CONFIGURATION A

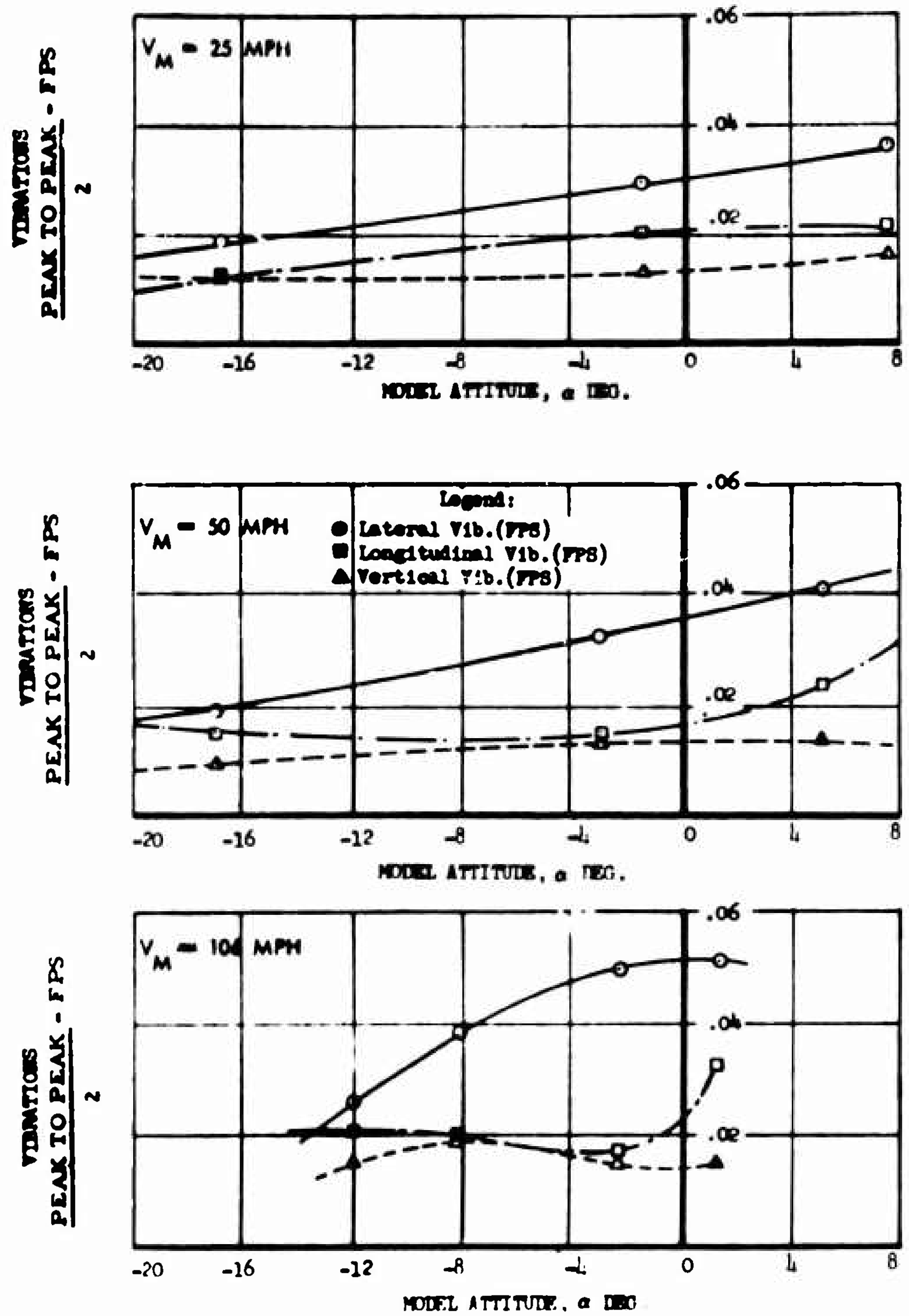

FIGURE 62 LATERAL, LONGITUDINAL, AND VERTICAL VIBRATIONS VS MODEL ATTITUDE FOR CONFIGURATION B

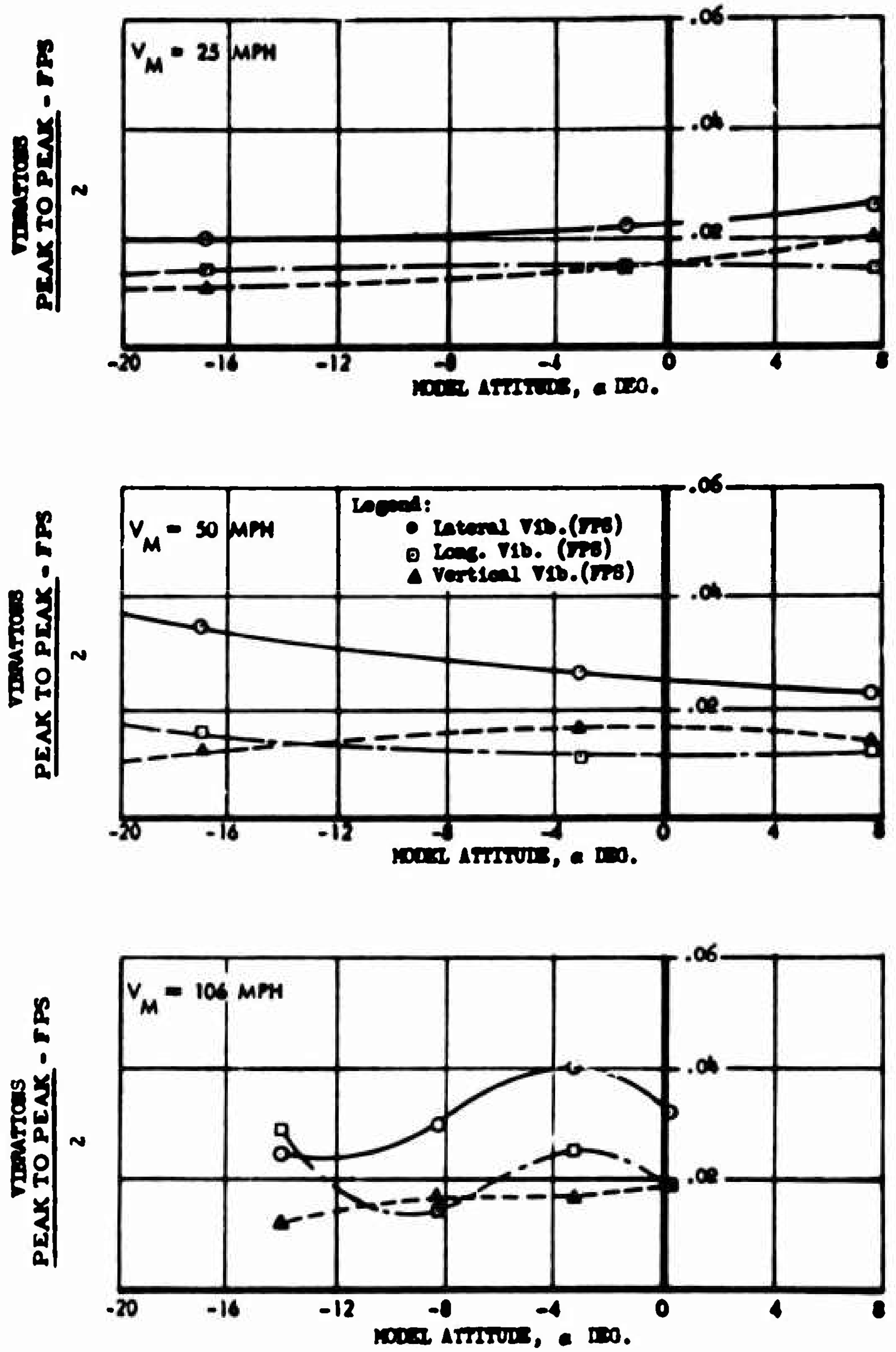

FIGURE 63 LATERAL, LONGITUDINAL, AND VERTICAL VIBRATIONS VS MODEL ATTITUDE FOR CONFIGURATION C

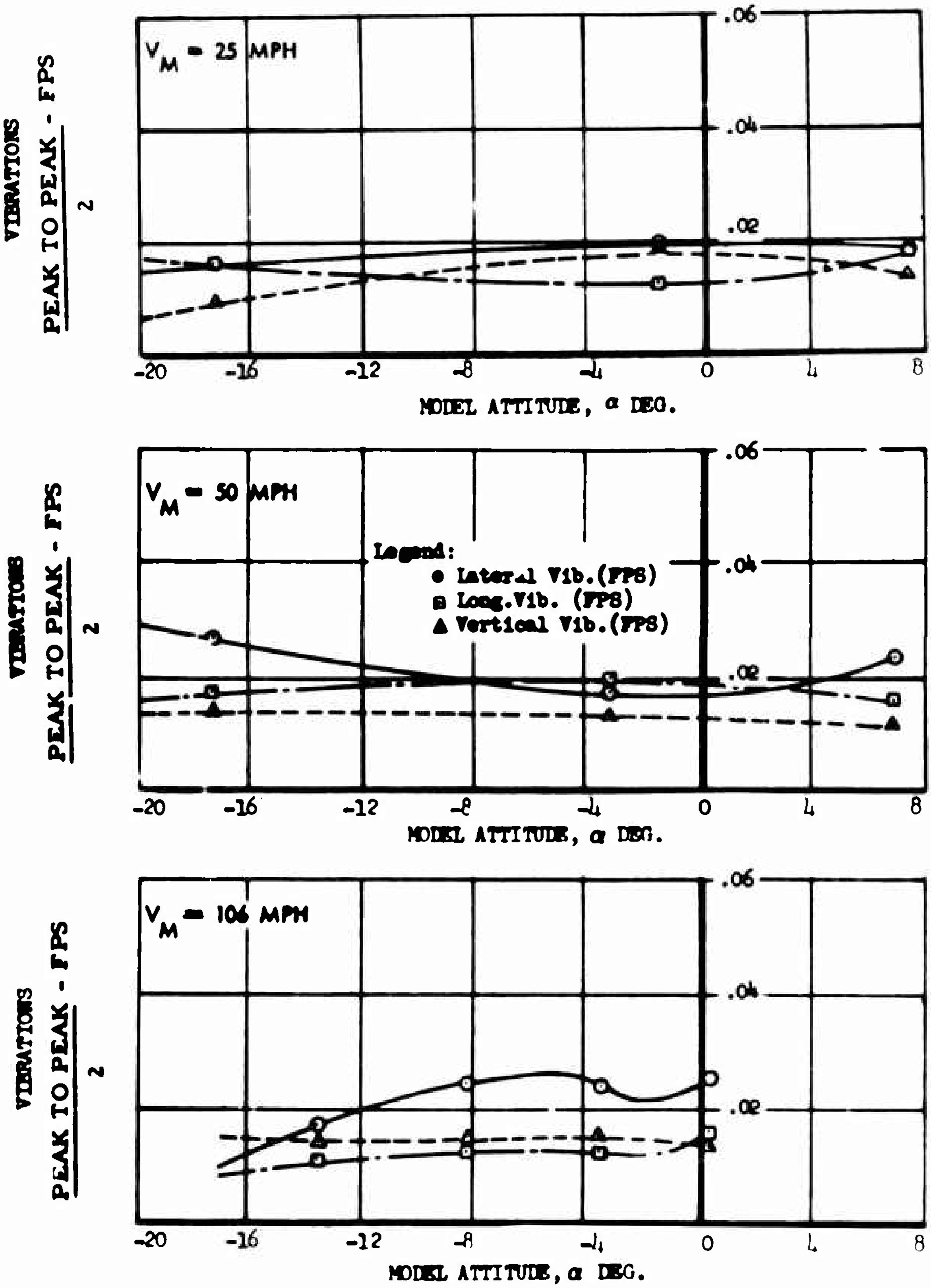

FIGURE 64 LATERAL, LONGITUDINAL AND VERTICAL VIBRATIONS VS MODEL ATTITUDE FOR CONFIGURATION D

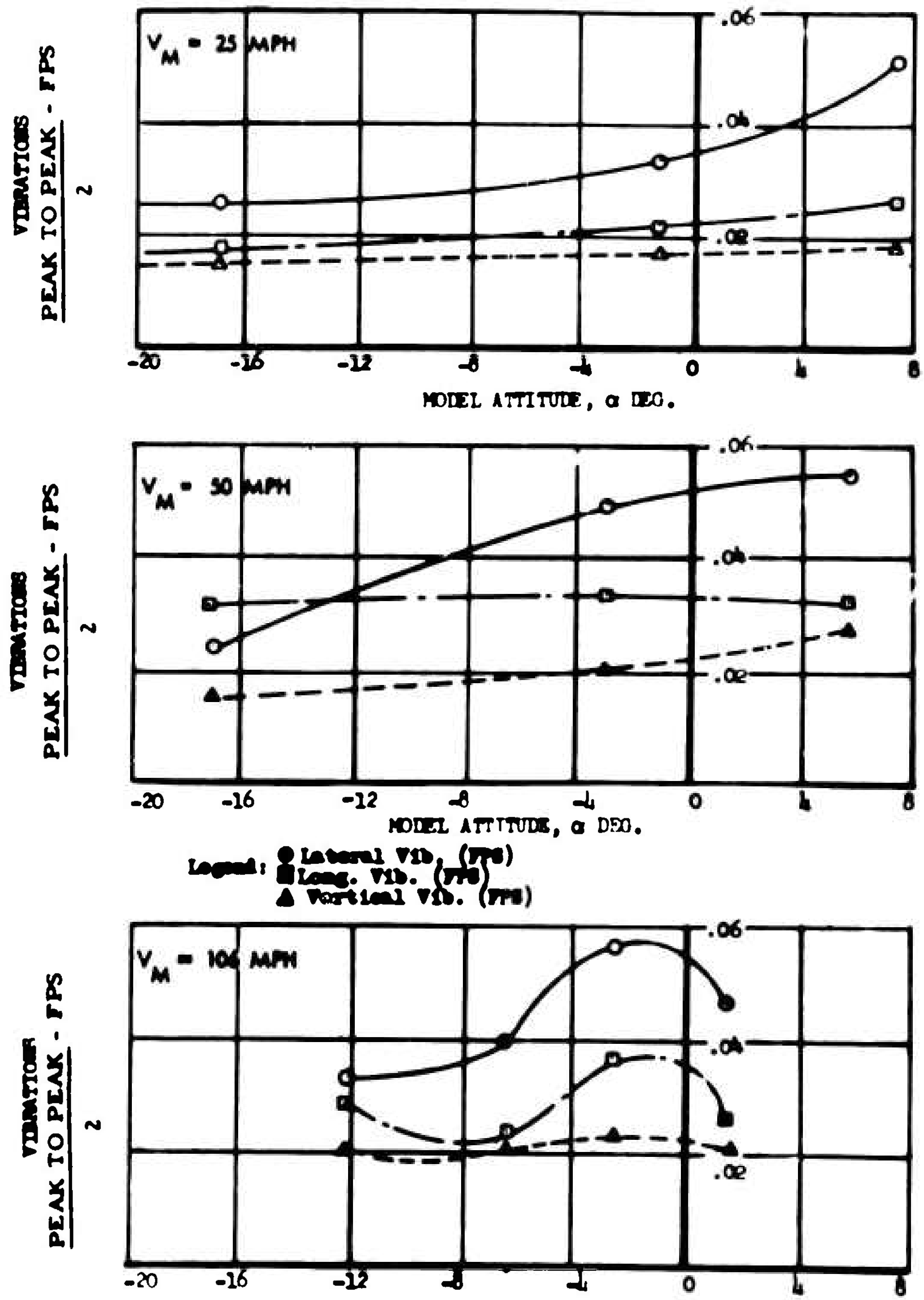

FIGURE 65 LATERAL, LONGITUDINAL, AND VERTICAL VIBRATIONS VS MODEL ATTITUDE FOR CONFIGURATION E

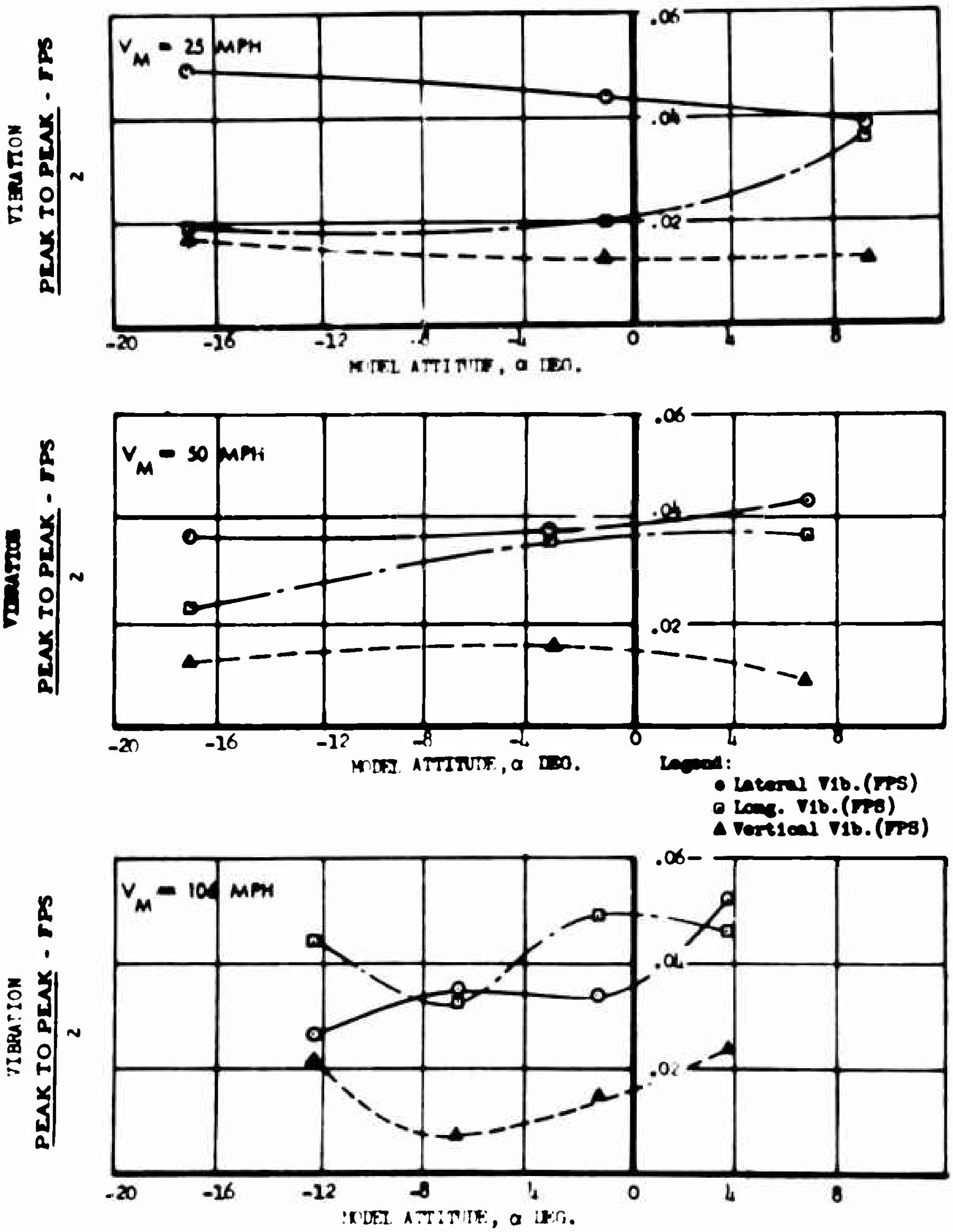

FIGURE 66 LATERAL, LONGITUDINAL, AND VERTICAL VIBRATIONS VS MODEL ATTITUDE FOR CONFIGURATION F

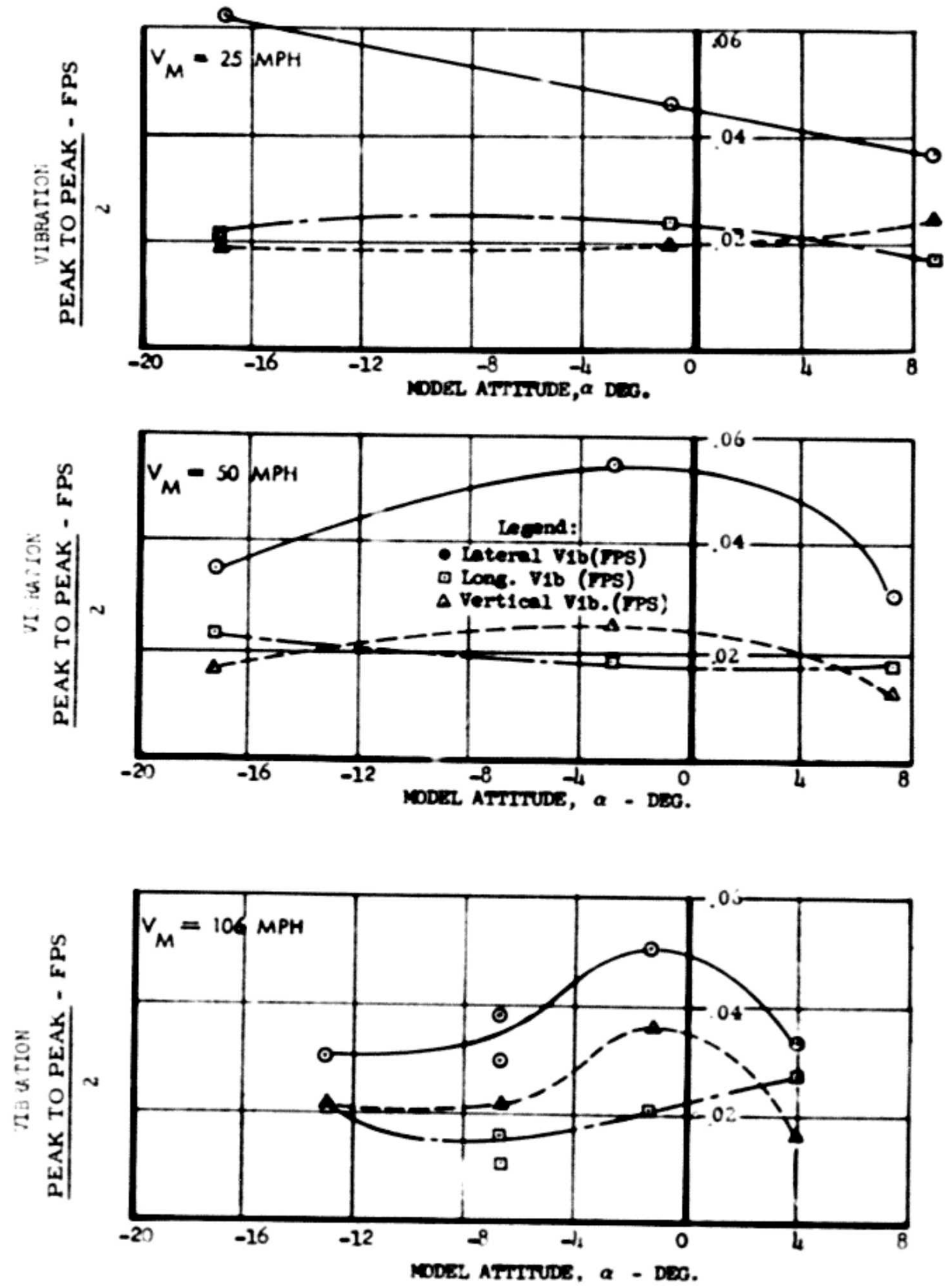

FIGURE 67 LATERAL, LONGITUDINAL, AND VERTICAL VIBRATIONS VS MODEL ATTITUDE FOR CONFIGURATION G

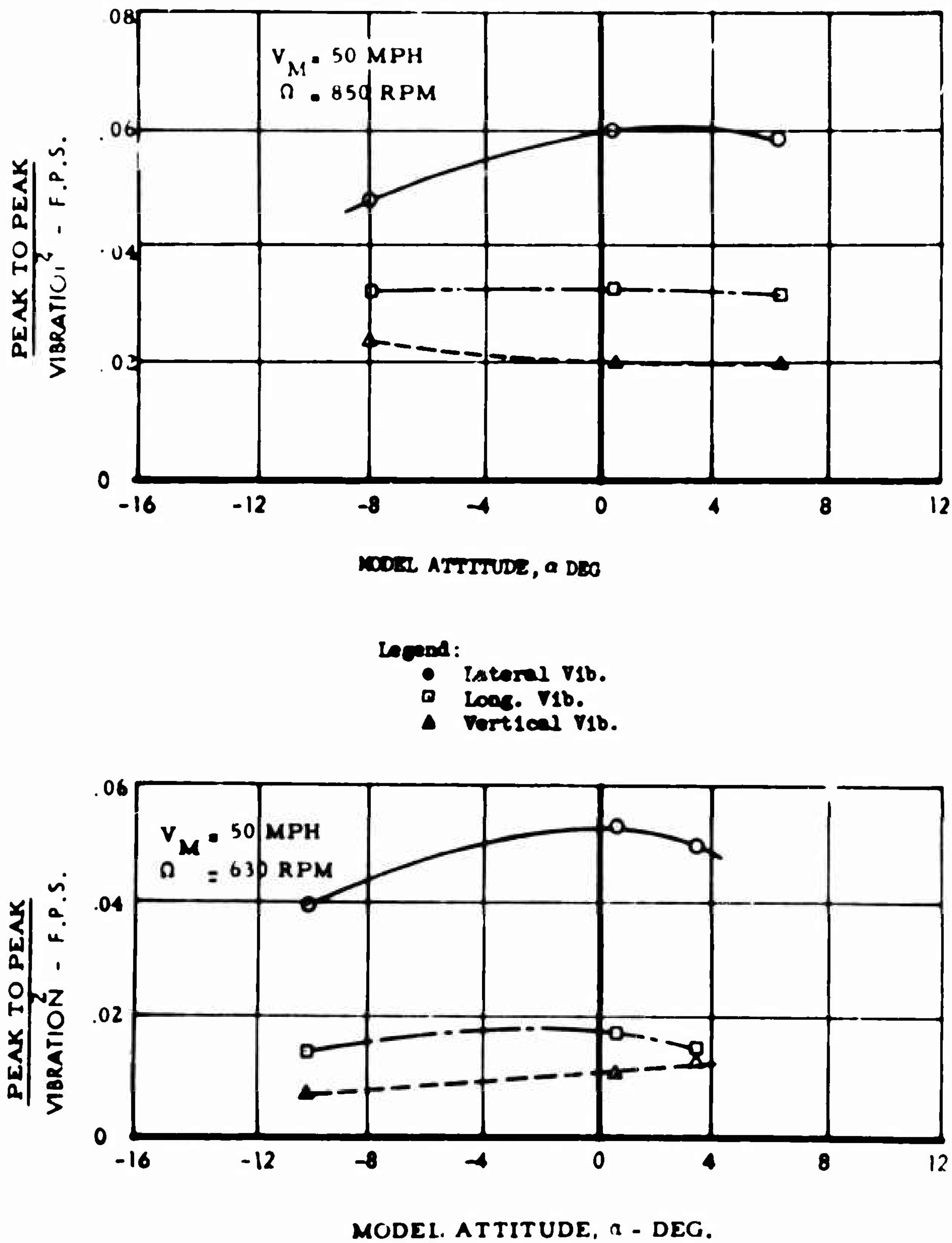

FIGURE 68 LATERAL, LONGITUDINAL, AND VERTICAL VIBRATIONS VS MODEL ATTITUDE FOR CONFIGURATION H

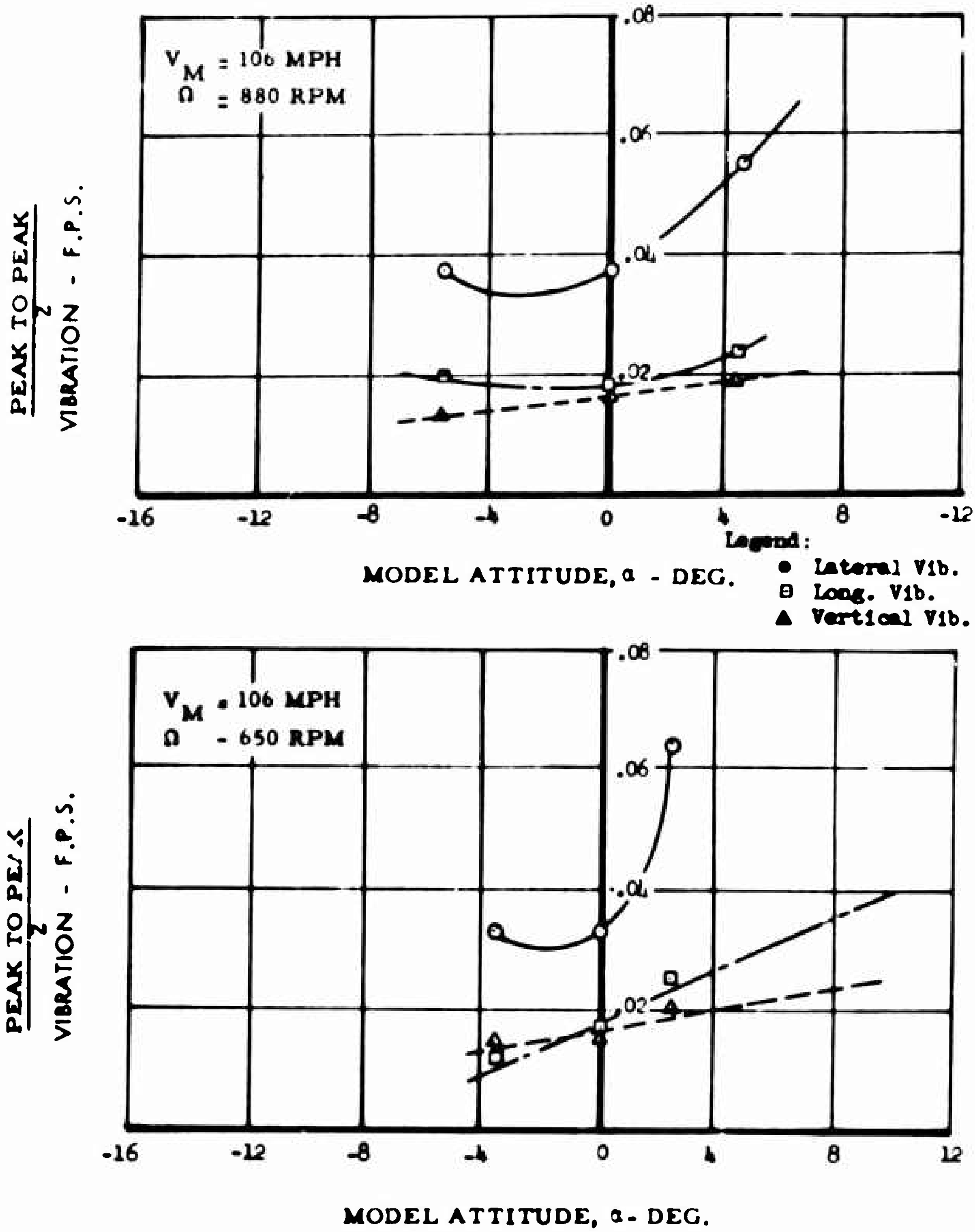

FIGURE 69 LATERAL, LONGITUDINAL, AND VERTICAL VIBRATIONS VS MODEL ATTITUDE FOR CONFIGURATION H

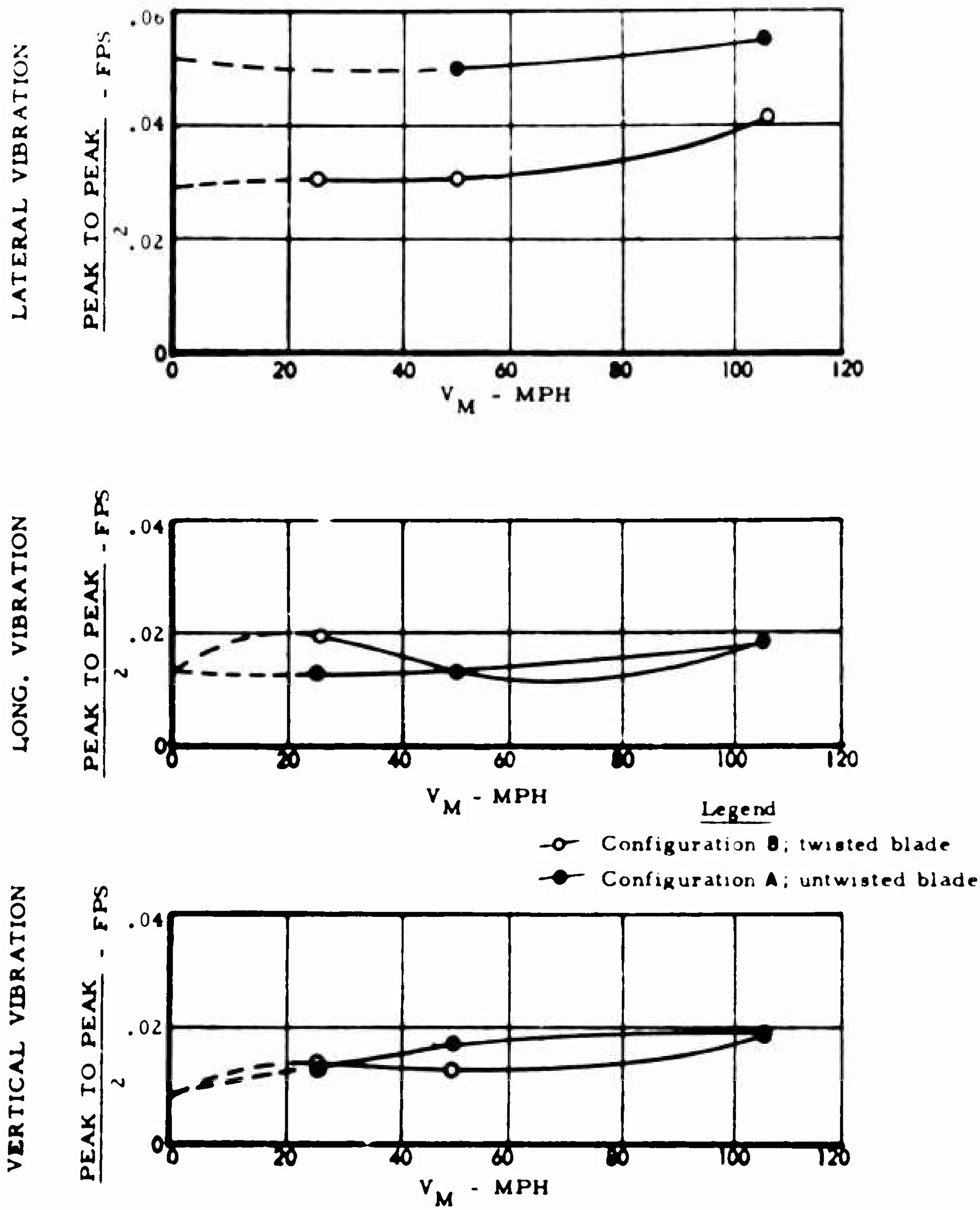

FIGURE 70 COMPARISON OF LATERAL, LONGITUDINAL AND VERTICAL VIBRATIONS BETWEEN CONFIGURATIONS A AND B

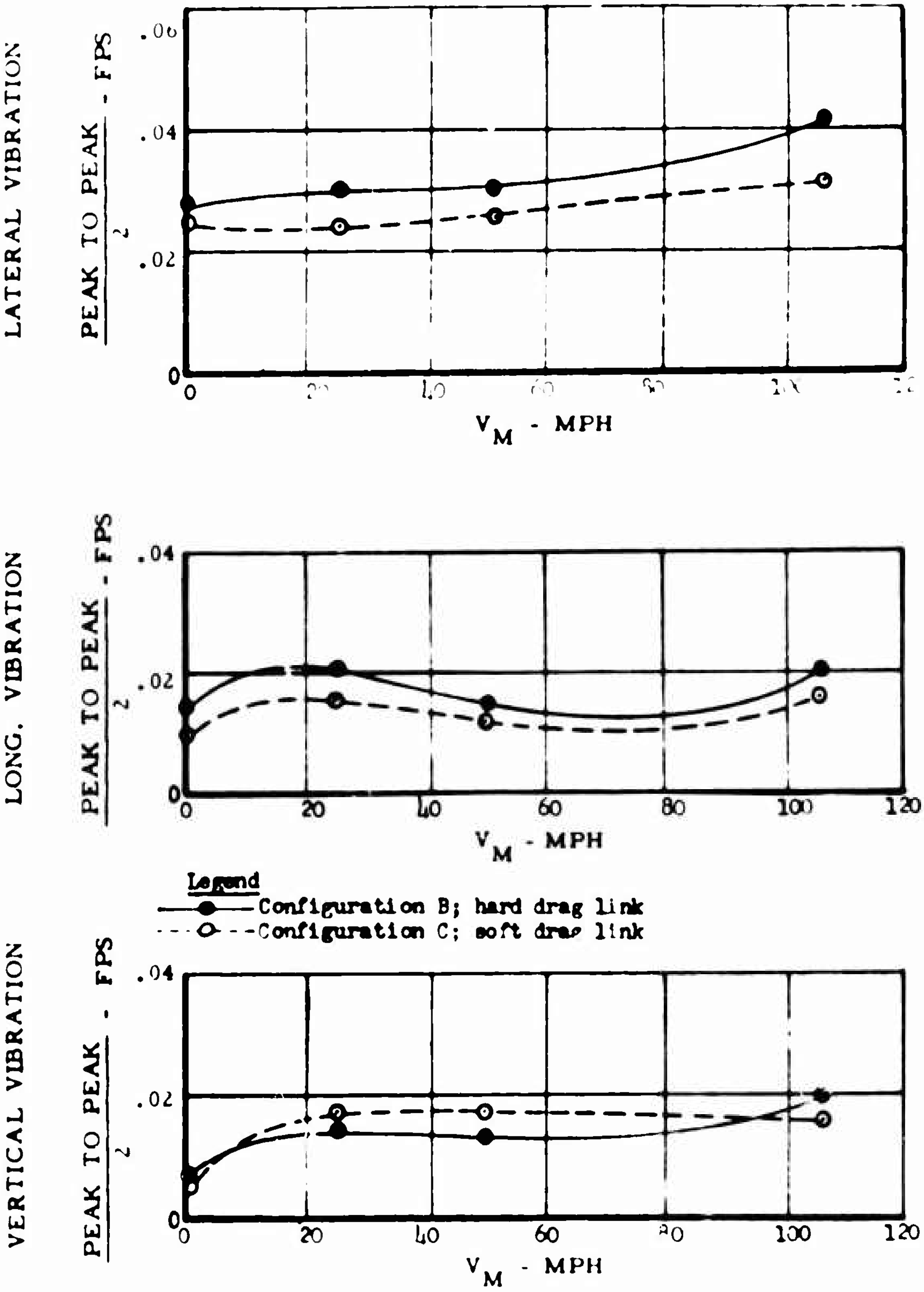

FIGURE 71 COMPARISON OF LATERAL, LONGITUDINAL, AND VERTICAL VIBRATIONS BETWEEN CONFIGURATIONS B AND C

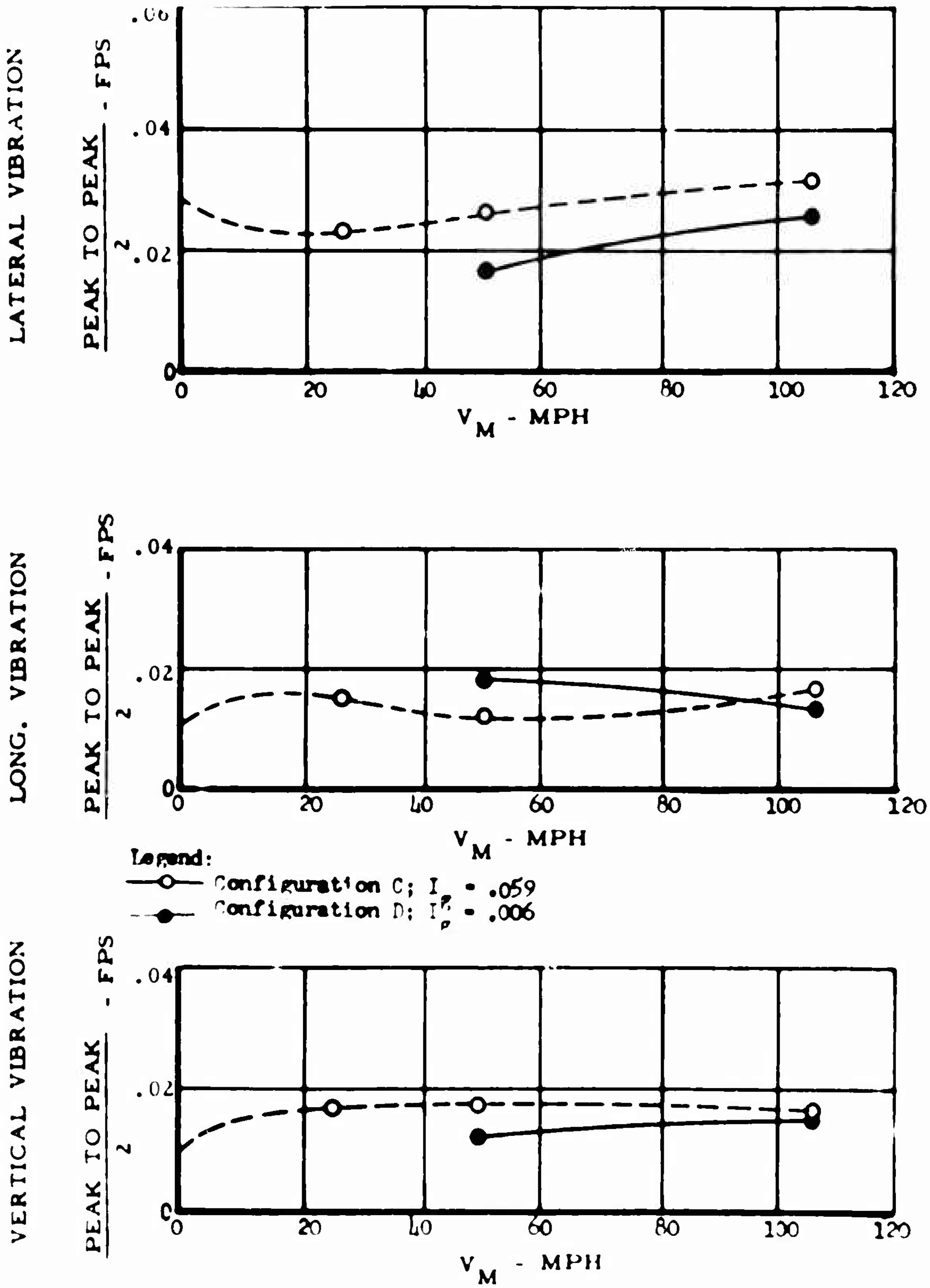

FIGURE 72 COMPARISON OF LATERAL, LONGITUDINAL, AND VERTICAL VIBRATIONS BETWEEN CONFIGURATIONS C AND D

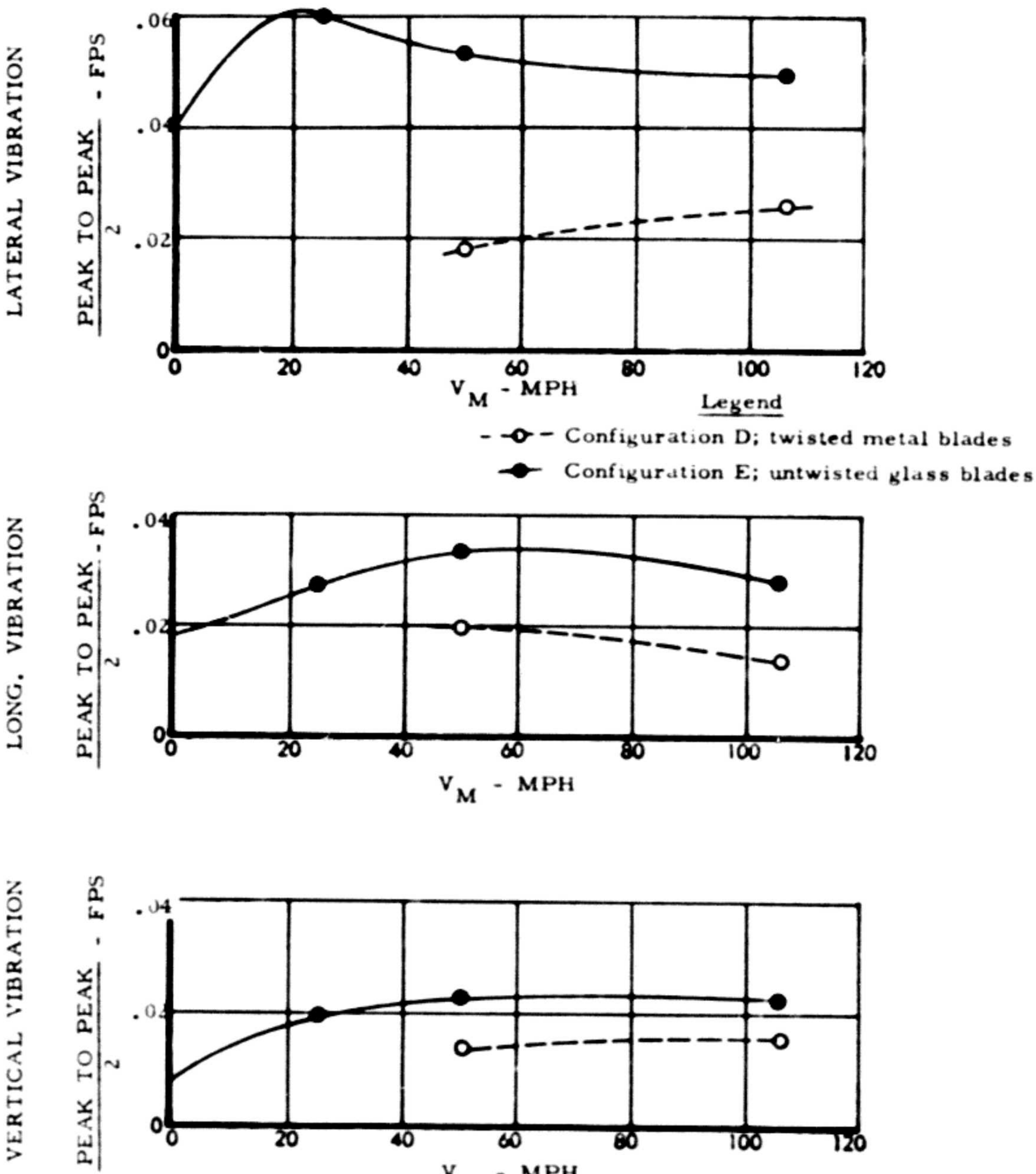

FIGURE 73 COMPARISON OF LATERAL, LONGITUDINAL, AND VERTICAL VIBRATIONS BETWEEN CONFIGURATIONS D AND E

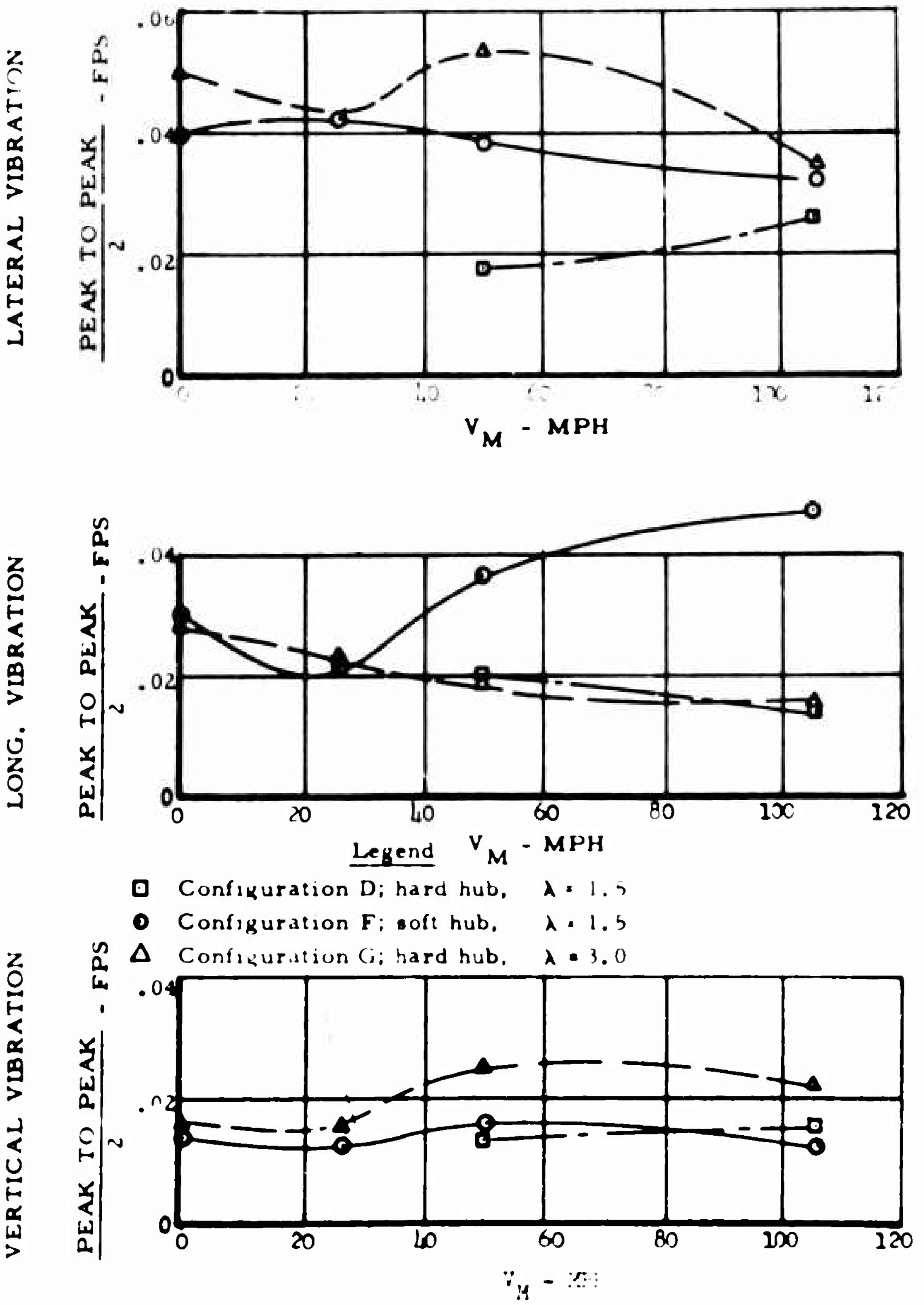

FIGURE 74 COMPARISON OF LATERAL, LONGITUDINAL, AND VERTICAL VIBRATIONS BETWEEN CONFIGURATIONS D, F, AND G

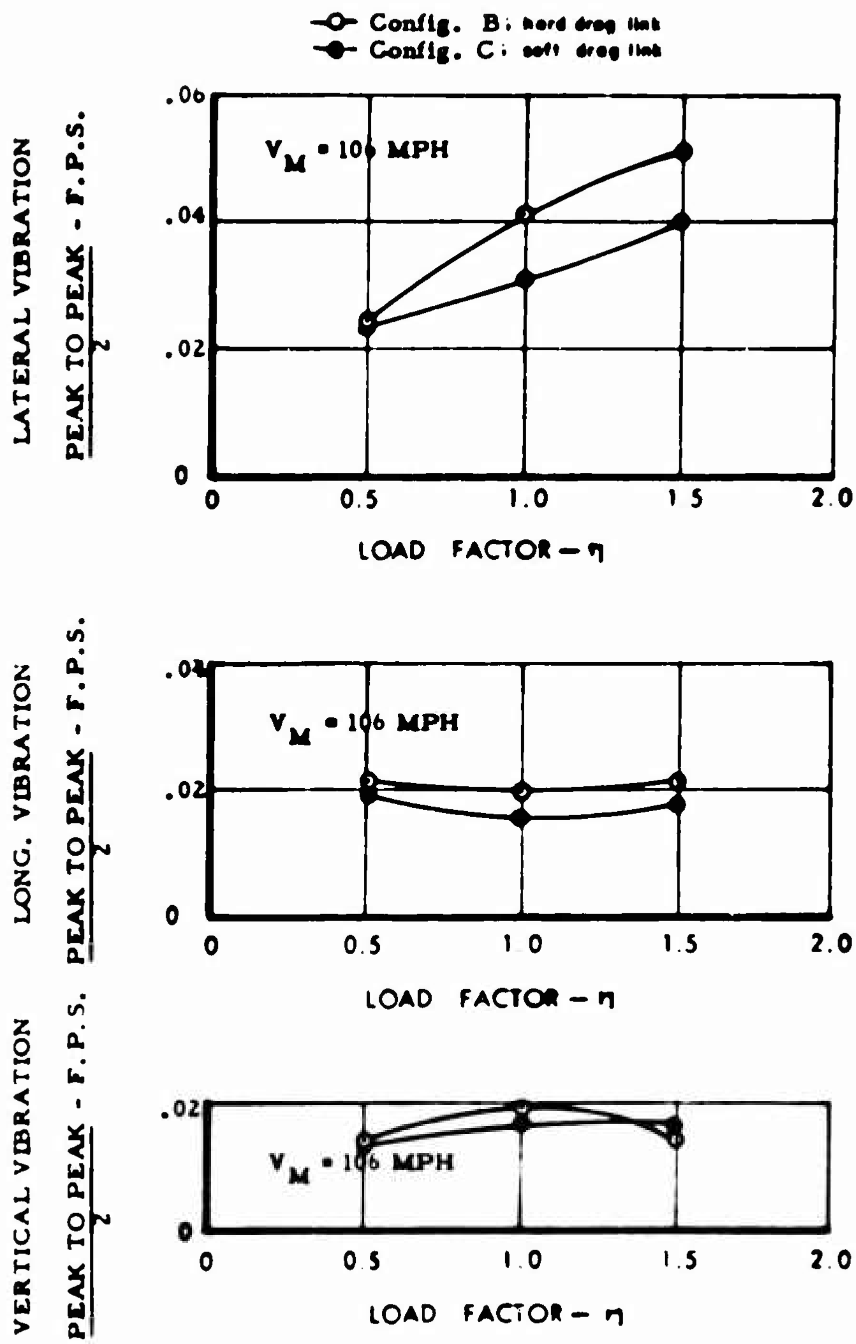

FIGURE 75 COMPARISON OF LATERAL, LONGITUDINAL, AND VERTICAL VIBRATIONS BETWEEN CONFIGURATIONS B AND C

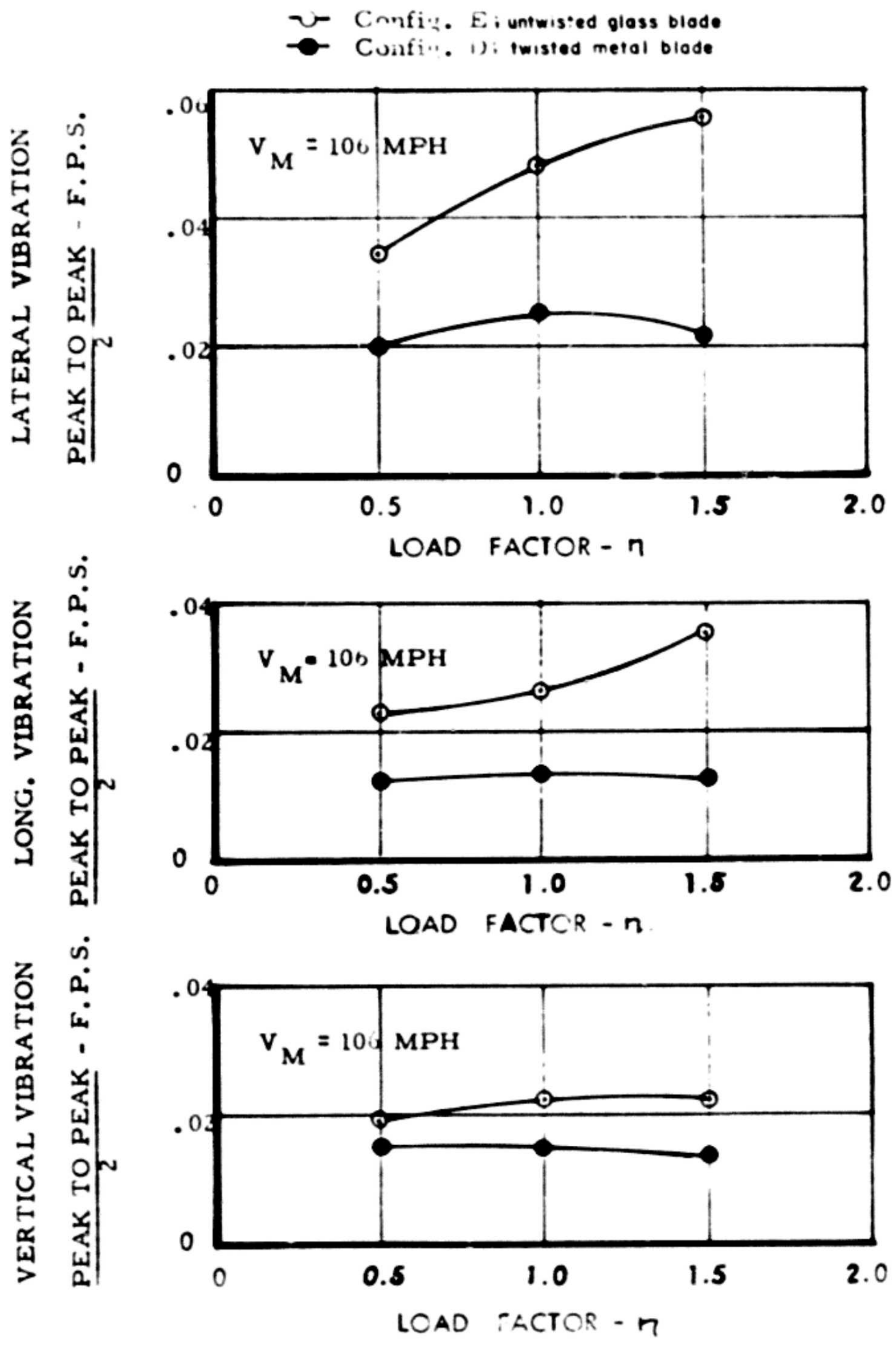

FIGURE 76 COMPARISON OF LATERAL, LONGITUDINAL, AND VERTICAL VIBRATIONS BETWEEN CONFIGURATIONS D AND E

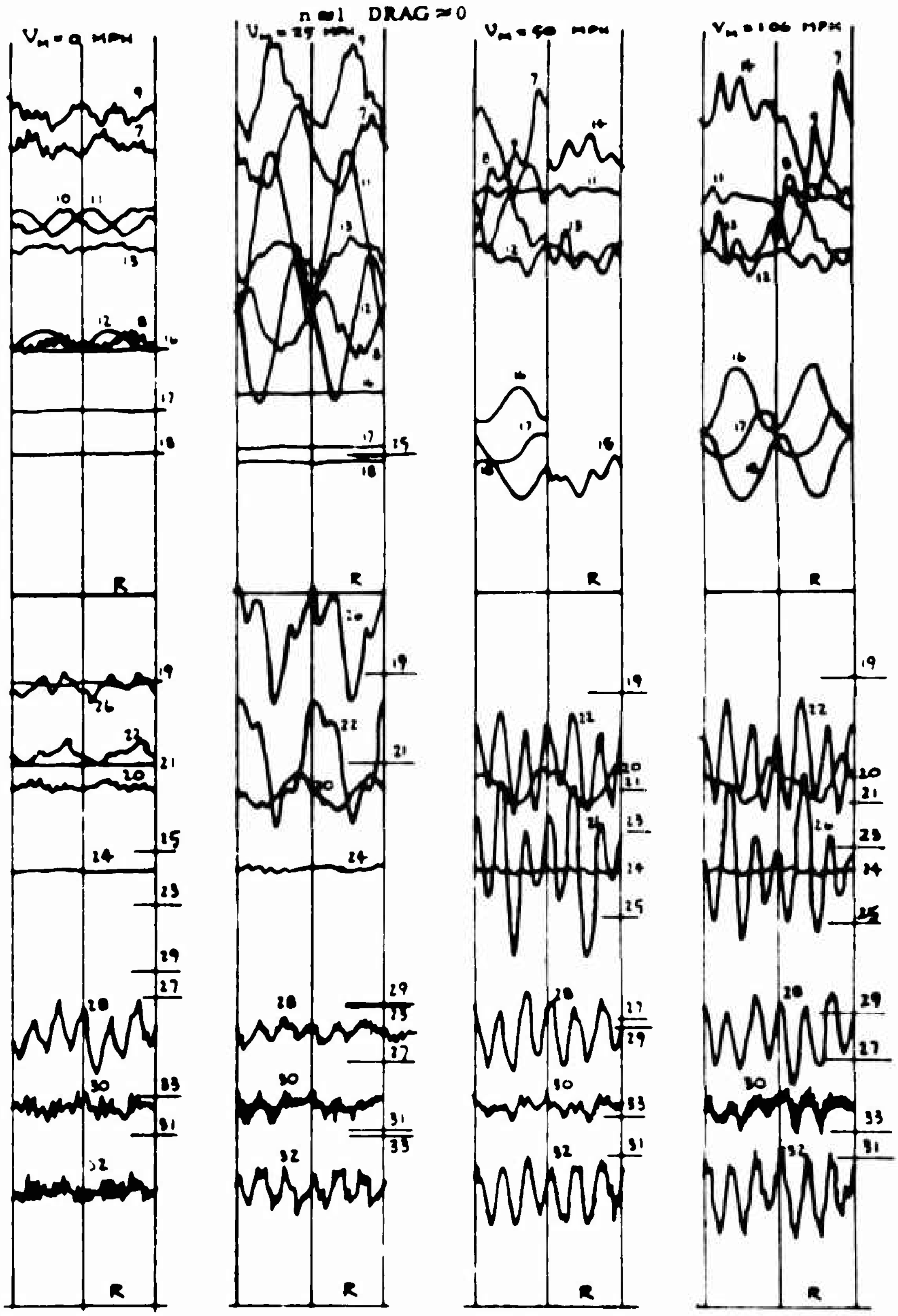

FIGURE 77 OSCILLOGRAM RECORDS - CONFIGURATION A

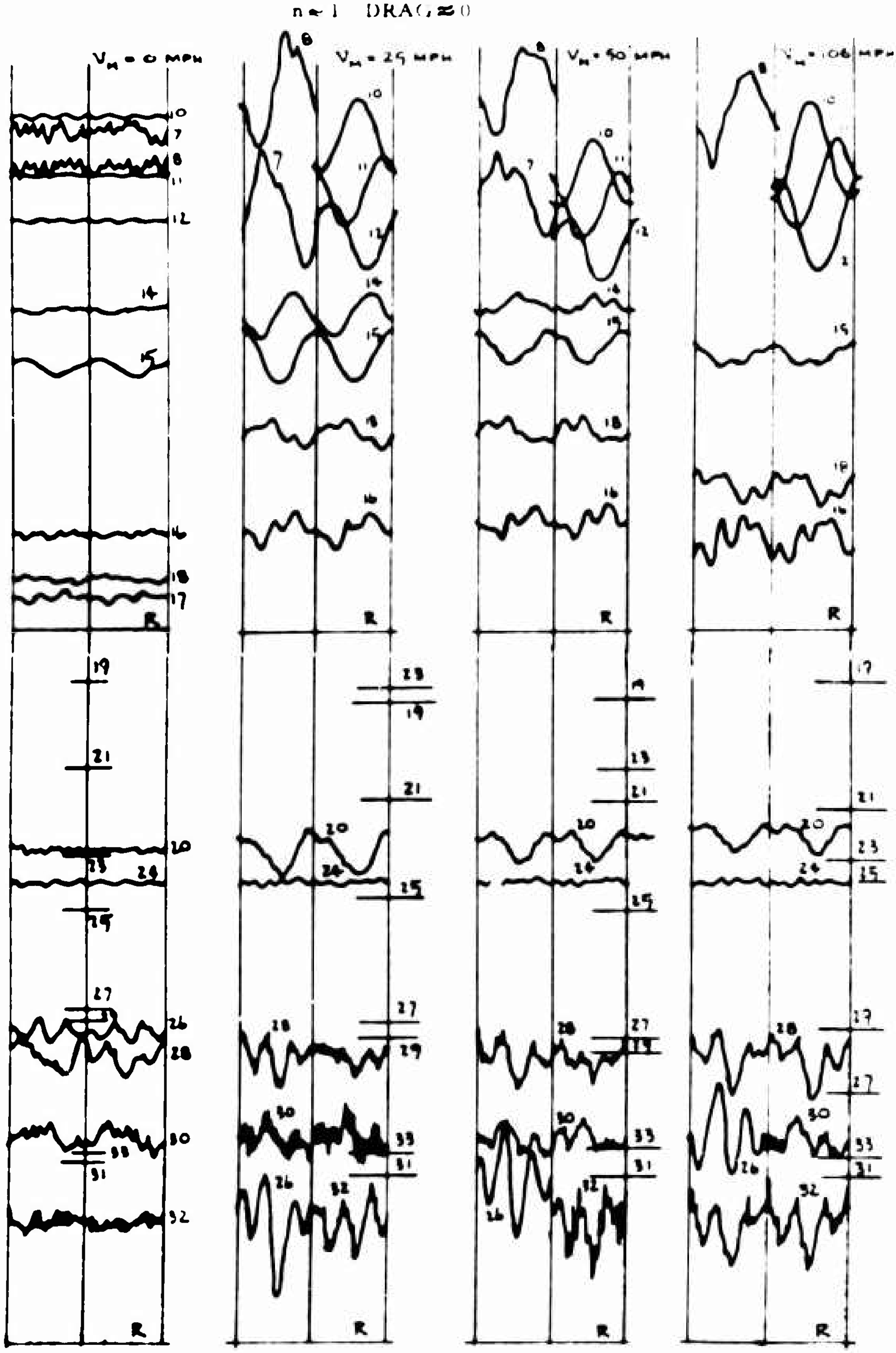

FIGURE 78 OSCILLOGRAM RECORDS - CONFIGURATION B

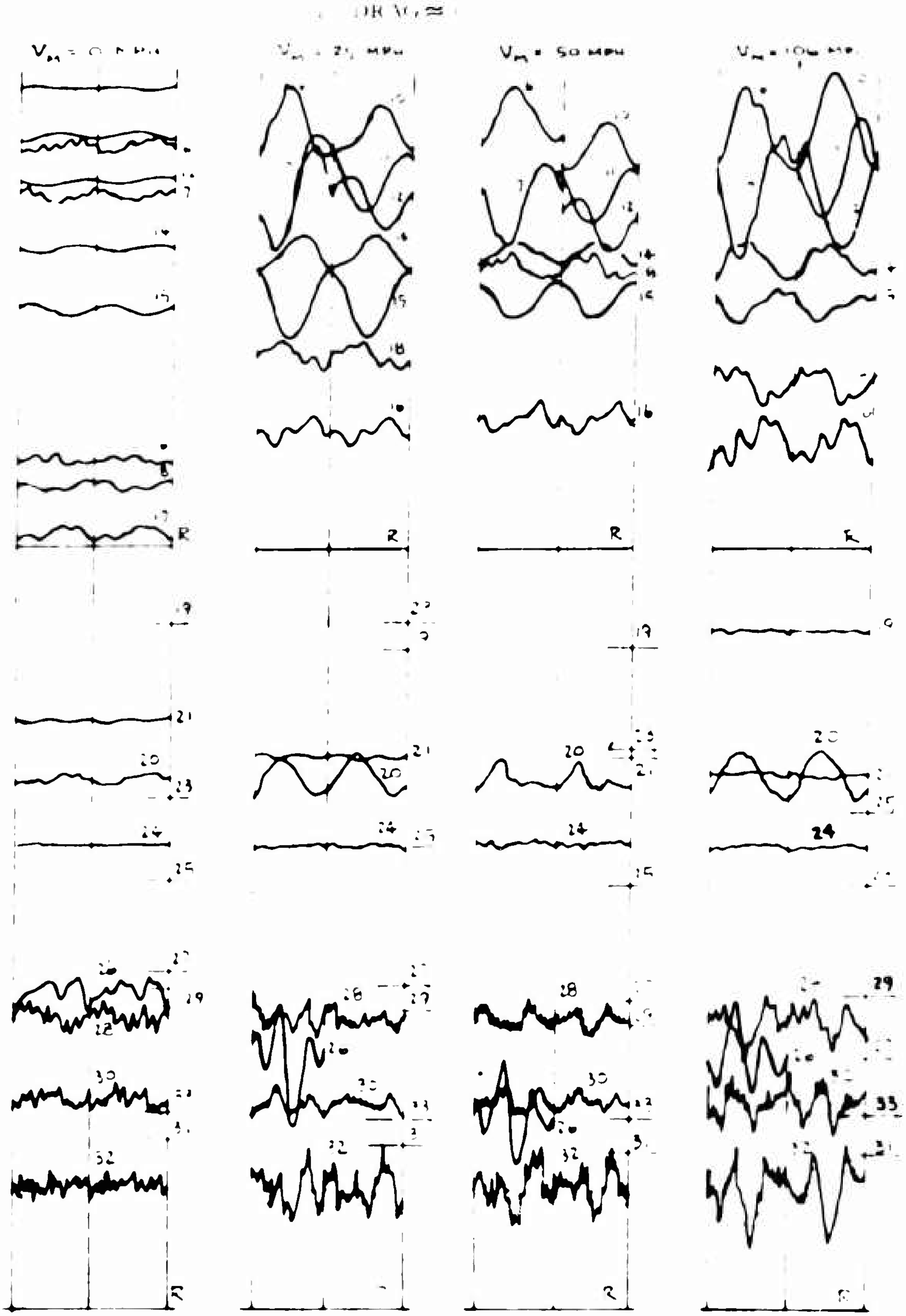

FIGURE 79 OSCILLOGRAM RECORDS - CONFIGURATION C

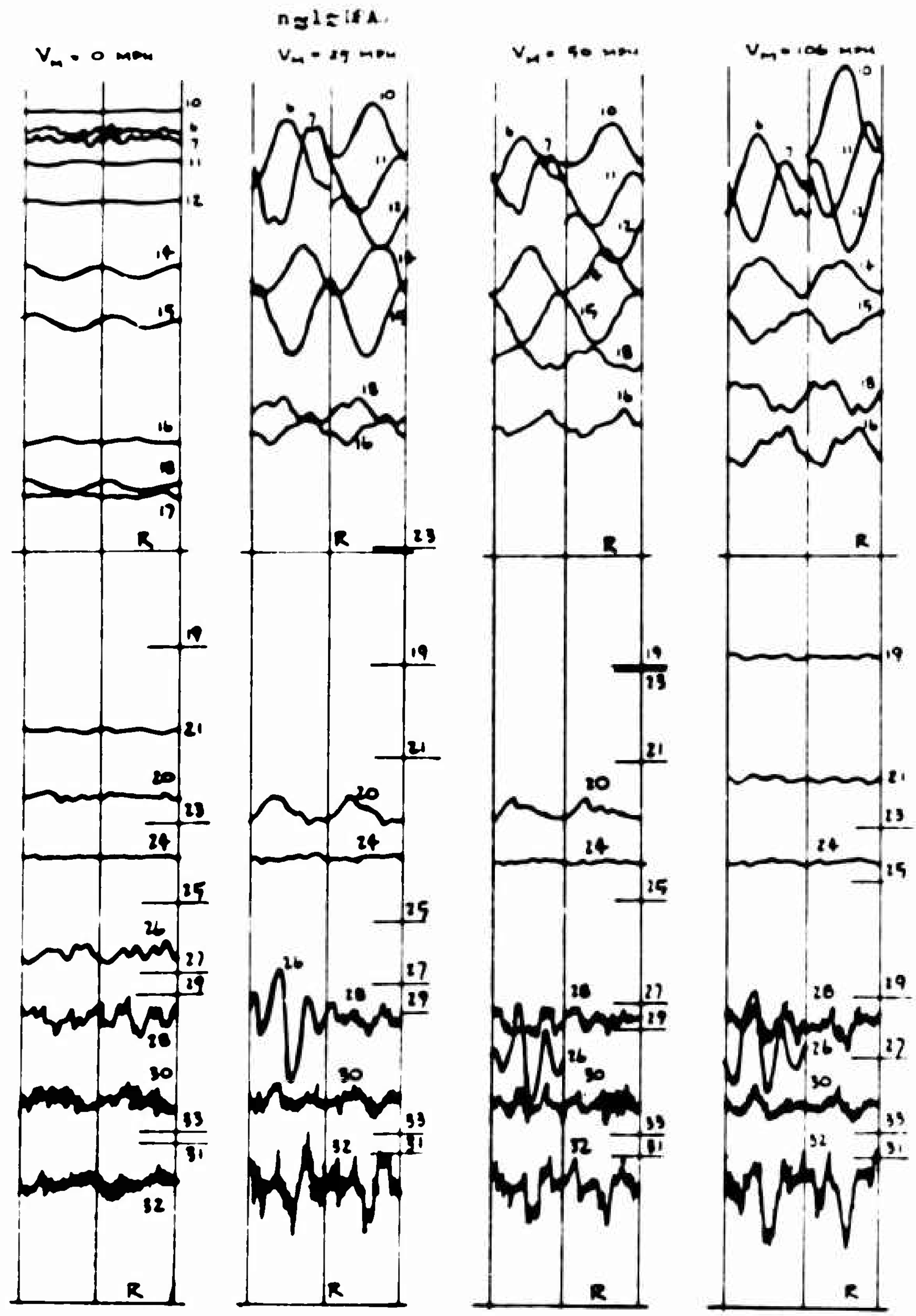

FIGURE 80 OSCILLOGRAM RECORDS - CONFIGURATION D

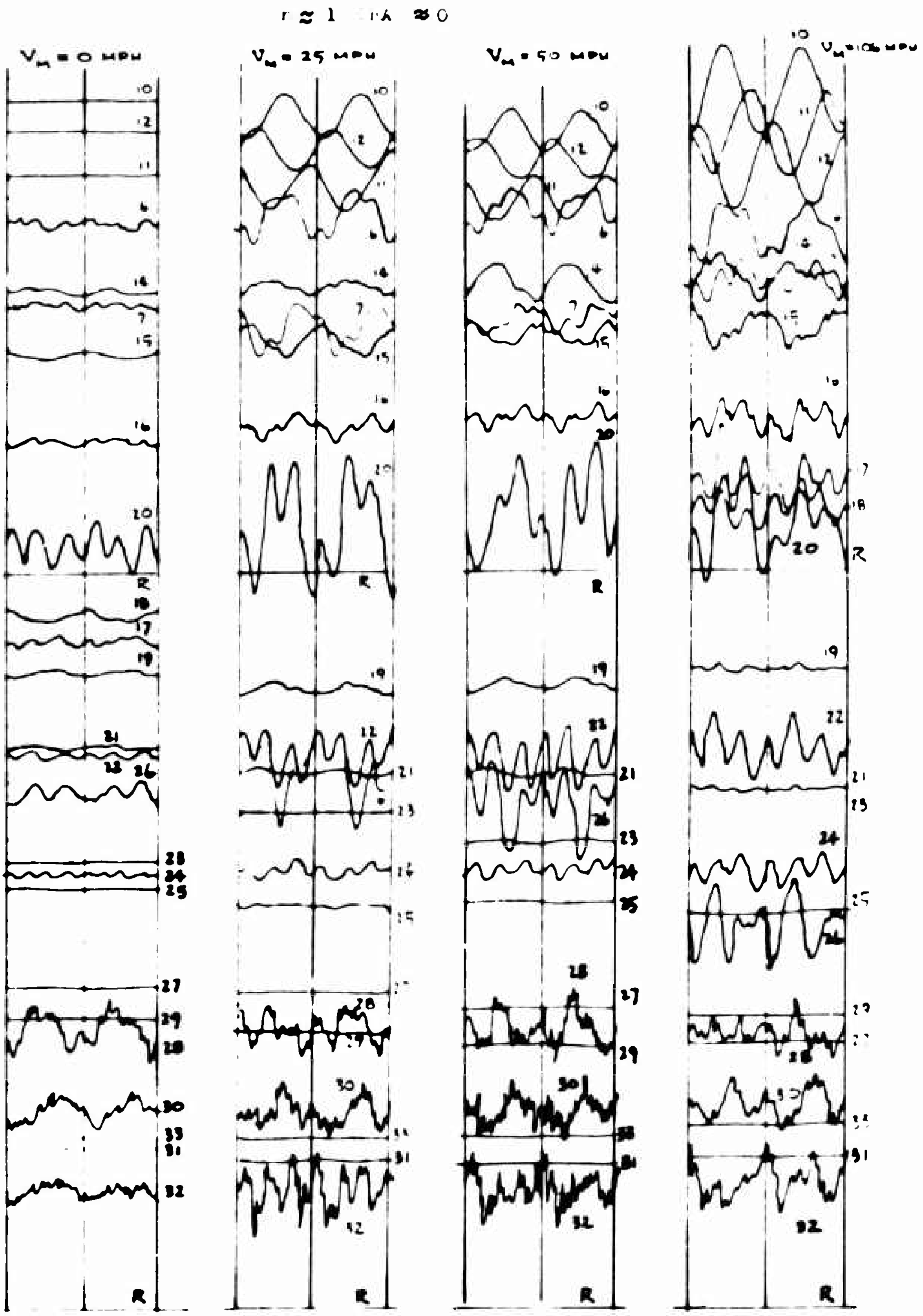

FIGURE 81 OSCILLOGRAM RECORDS - CONFIGURATION E

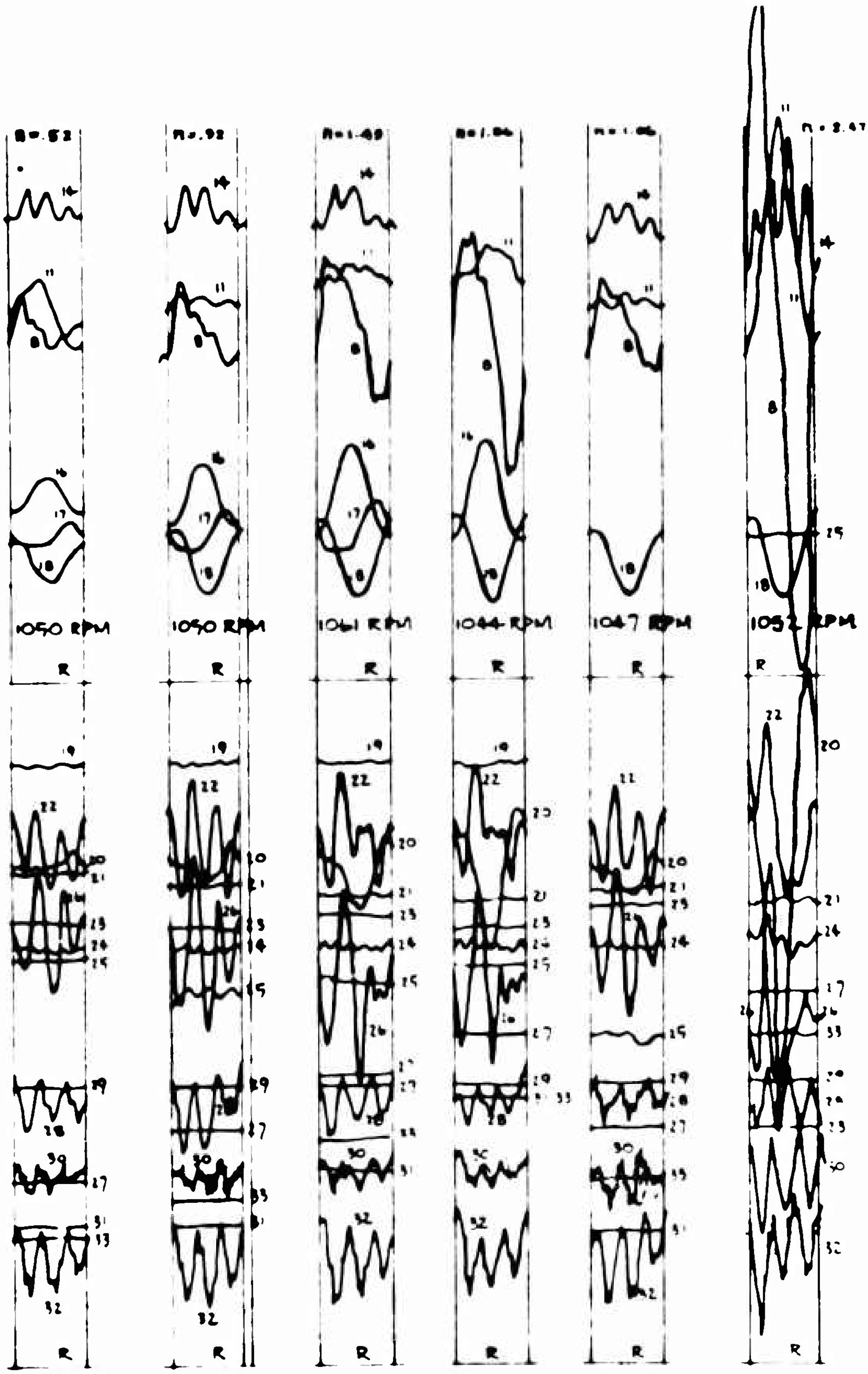

FIGURE 82 OSCILLOGRAM RECORDS FOR VARIOUS n AT CONSTANT V_M - CONFIGURATION A

REFERENCES

1. U. S. Army Contract No. DA 44-177-TC-828, Rigid Rotor Model Study.
2. Kanno, J. S., and Lundgren, S., Equations of Motion for the Dynamic Analysis of a Hovering Rotor Including Gyro Control System, Lockheed California Company, LR 17185, June, 1961
3. Kanno, J. S., and Lundgren, S., 10-Foot Rigid Rotor Model Basic Data and Results of Hovering Cyclic Stability Analysis, LR 16997, July 1963.
4. Bailey, F.J. Jr., A Simplified Theoretical Method of Determining the Characteristics of a Lifting Rotor in Forward Flight, NACA Rep. No. 716 1941.
5. Bailey, F. J., Jr., and Gustafson, F. B. Charts for Estimation of the Characteristics of a Helicopter Rotor in Forward Flight, I- Profile Drag-Lift Ratio for Untwisted Rectangular Blades, NACA ACR L4H07 1944.
6. Gustafson, F. B., Charts for Estimation of the Profile Drag - Lift Ratio of a Helicopter Rotor Having Rectangular Blades with -8° Twist, NACA RM L53G20a 1953.
7. Gessow, A., and Crim, A. D., A Method for Studying the Transient Blade - Flapping Behavior of Lifting Rotors at Extreme Operating Conditions, NACA TN 3366 1955.
8. Gessow, A., Equations and Procedure for Numerically Calculating the Aerodynamic Characteristics of Lifting Rotors, NACA TN 3747 1956.

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APPENDIX

FULL SCALE TUNNEL AND TRANS DYNAMIC TUNNEL DATA

(Description of test configurations are presented)

TABLE 4

INDEX OF TEST DATA

ITEM	TRACE NO.	ZERO (INCHES)	CALIBRATION FACTOR	
#1 - Drag Link	7	4.08	296	lbs/in
#2 - Drag Link	8	3.71	367	lbs/in
#3 - Drag Link	9	3.42	286	lbs/in
#1 - Inbd Flap	10	-	-	
#2 - Inbd. Flap	11	2.85	954	in-lbs/in
#3 - Inbd Flap	12	2.55	921	in-lbs/in
#1 - Pitch Link	13	2.22	-134	lbs/in
#2 - Pitch Link	14	1.93	-140	lbs/in
#3 - Pitch Link	15			
#1 - Mid Chord	20	4.48	2,000	in-lbs/in
#1 - Mid Flap	22	3.87	334	in-lbs/in
#1 - Mid Torsion	24	3.30	-1,310	in-lbs/in
#1 - Outbd. Flap	26	2.73	144	in-lbs/in
Model Attitude	27	2.41	13.4	deg/in
Collective Pitch	29	1.60	12.4	deg/in
#1 - Cyclic Pitch	16	1.09	10.6	deg/in
#2 - Cyclic Pitch	17	0.77	12.6	deg/in
#3 - Cyclic Pitch	18	0.40	11.8	deg/in
Gyro Roll Pos.	19	4.85	9.9	deg/in
Gyro Pitch Pos.	21	4.19	9.0	deg/in
Thrust	33	0.62		lbs/in
Drag	31	1.18	80	lbs/in
Roll Moment	23	3.00	520	in-lbs/in
Pitch Moment	25	3.00	400	in-lbs/in
Lat. Vibration	28		0.171	fps/in
Long. Vibration	30		0.114	fps/in
Vert. Vibration	32		0.067	fps/in

NOTE: PITCH LINK = INBOARD TORSION

SIGN CONVENTION

DRAG LINK & PITCH LINK: TENSION IS POSITIVE
FLAPWISE BENDING: COMPRESSION UPPER SURFACE IS POSITIVE
CHORDWISE BENDING: COMPRESSION L. E. IS POSITIVE
TORSION: NOSE UP ACTION LOAD IS POSITIVE
ALL NOSE UP PITCH ANGLES ARE POSITIVE
ALL RIGHT SIDE DOWN ROLL ANGLES ARE POSITIVE

TABLE 5 CALIBRATION FACTORS FOR MEASUREMENT OF DYNAMIC LOADS - CONFIGURATION A
TEST DATES: NOV. 30, 1962 - DEC. 4, 1962

ITEM	TRACE NO.	ZERO (INCHES)	CALIBRATION FACTOR	
#1 - DRAG LINK	6	4.22	-	109 (S) LBS/IN.
#2 - DRAG LINK	7	3.94	354 (H) LBS/IN.	112 (S) LBS/IN.
#3 - DRAG LINK	8	3.70	295 (H) LBS/IN.	-
#1 - INBOARD F	13	-	-	-
#2 - INBOARD F	14	1.89	990	IN-LBS/IN.
#3 - INBOARD F	15	1.64	980	IN-LBS/IN.
#1 - PITCH LINK	16	1.30	132	LBS/IN.
#2 - PITCH LINK	17	1.00	138	LBS/IN.
#3 - PITCH LINK	18	0.75	157	
#1 - MIDSPAN C	20	4.44	1,760	IN-LBS/IN.
#1 - MIDSPAN F	22	3.83	300	IN-LBS/IN.
#1 - MIDSPAN T	24	3.30	1,490	IN-LBS/IN.
#1 - OUTBD. F	26	2.64	190	IN-LBS/IN.
MODEL ATTITUDE	27	2.41	13.4	DEG/IN.
COLL. PITCH	29	1.58	11.4	DEG/IN.
#1-CYCLIC PITCH	10	2.90	11.4	DEG/IN.
#2-CYCLIC PITCH	11	2.63	11.6	DEG/IN.
#3-CYCLIC PITCH	12	2.33	12.2	DEG/IN.
GYRO ROLL POS.	19	4.72	9.9	DEG/IN.
GYRO PITCH POS.	21	4.12	9.0	DEG/IN.
THRUST	33	0.62	390	LBS/IN.
DRAG	31	1.18	80	LBS/IN.
ROLL MOMENT	23	3.56	263	IN-LBS/IN.
PITCH MOMENT	25	2.95	357	IN-LBS/IN.
LAT. VIBRATION	28	-	0.171	FPS/IN.
LONG. VIBRATION	30	-	0.114	FPS/IN.
VERT. VIBRATION	32	-	0.057	FPS/IN.

NOTE: PITCH LINK = INBOARD TORSION

H = HARD DRAG LINK, S = SOFT DRAG LINK

SIGN CONVENTION

DRAG LINK & PITCH LINK: TENSION IS POSITIVE
FLAPWISE BENDING: COMPRESSION UPPER SURFACE IS POSITIVE
CHORDWISE BENDING: COMPRESSION L.E. IS POSITIVE
TORSION: NOSE UP ACTION LOAD IS POSITIVE
ALL NOSE UP PITCH ANGLES ARE POSITIVE
ALL RIGHT SIDE DOWN ROLL ANGLES ARE POSITIVE

TABLE 6 CALIBRATION FACTORS FOR MEASUREMENT OF DYNAMIC LOADS - CONFIGURATIONS B, C, AND D
TEST DATE: DEC. 7, 1962

ITEM	TRACE NO.	ZERO (INCHES)	CALIBRATION FACTOR	
#1 - DRAG LINK	6	4.29	59	LBS/IN.
#2 - DRAG LINK	7	3.79	67	LBS/IN.
#3 - DRAG LINK	8	-	-	
#1 - INBOARD F	13	-	-	
#2 - INBOARD F	14	2.21	1,000	IN-LBS/IN.
#3 - INBOARD F	15	1.91	1,010	IN-LBS/IN.
#1 - PITCH LINK	16	1.32	156	LBS/IN.
#2 - PITCH LINK	17	0.97	146	LBS/IN.
#3 - PITCH LINK	18	0.70	151	LBS/IN.
#1 - MIDSPAN C	20	4.45	118	IN-LBS/IN.
#1 - MIDSPAN F	22	-	-	
#1 - MIDSPAN T	24	-	-	
#1 - OUTBD. F	26	-	-	
MODEL ATTITUDE	27	2.41	13.4	DEG/IN.
COLL. PITCH	29	1.58	11.4	DEG/IN.
#1 - CYCLIC PITCH	10	2.90	11.4	DEG/IN.
#2 - CYCLIC PITCH	11	2.63	11.6	DEG/IN.
#3 - CYCLIC PITCH	12	2.33	12.2	DEG/IN.
GYRO ROLL POS.	19	4.72	9.9	DEG/IN.
GYRO PITCH POS.	21	4.12	9.0	DEG/IN.
THRUST	33	0.62	390	LBS/IN.
DRAG	31	1.18	80	LBS/IN.
ROLL MOMENT	23	3.56	263	IN-LBS/IN.
PITCH MOMENT	25	2.95	357	IN-LBS/IN.
LAT. VIBRATION	28	-	0.171	FPS/IN.
LONG. VIBRATION	30	-	0.114	FPS/IN.
VERT. VIBRATION	32	-	0.057	FPS/IN.

NOTE: PITCH LINK = INBOARD TORSION

SIGN CONVENTION

DRAG LINK & PITCH LINK: TENSION IS POSITIVE
FLAPWISE BENDING: COMPRESSION UPPER SURFACE IS POSITIVE
CHORDWISE BENDING: COMPRESSION L.E. IS POSITIVE
TORSION: NOSE UP ACTION LOAD IS POSITIVE
ALL NOSE UP PITCH ANGLES ARE POSITIVE
ALL RIGHT SIDE DOWN ROLL ANGLES ARE POSITIVE

TABLE 7 CALIBRATION FACTORS FOR MEASUREMENT OF DYNAMIC LOADS - CONFIGURATION E
TEST DATES: DEC. 11, 1962 - DEC. 13, 1962

ITEM	TRACE NO.	ZERO (INCHES)	CALIBRATION FACTOR
#1 - DRAG LINK	6		91 LBS/IN.
#2 - DRAG LINK	7		121 LBS/IN.
#3 - DRAG LINK	8		-
#1 - INBOARD FLAP	13		-
#2 - INBOARD FLAP	14		1110 IN-LBS/IN.
#3 - INBOARD FLAP	15		1000 IN-LBS/IN.
#1 - PITCH LINK	16		146 LBS/IN.
#2 - PITCH LINK	17		142 LBS/IN.
#3 - PITCH LINK	18		-
#1 - MIDSPAN CHORD	20		1640 IN-LBS/IN.
#1 - MIDSPAN FLAP	22		-
#1 - MIDSPAN TORS.	24		1500 IN-LBS/IN.
#1 - OUTBOARD FLAP	26		184 IN-LBS/IN.
MODEL ATTITUDE	27	2.34*	14 DEG/IN.
COLL. PITCH	29		11.1 DEG/IN.
#1 - CYCLIC PITCH	10		10.7 DEG/IN.
#2 - CYCLIC PITCH	11		12.3 DEG/IN.
#3 - CYCLIC PITCH	12		11.3 DEG/IN.
GYRO ROLL	19		10.0 DEG/IN.
GYRO PITCH	21		13.0 DEG/IN.
THRUST	33	.45**	385 LBS/IN.
DRAG	31		156 LBS/IN.
ROLL MOMENT	23		417 IN-LBS/IN.
PITCH MOMENT	25		380 IN-LBS/IN.
LAT. VIBRATION	28		.171 FPS/IN.
LONG. VIBRATION	30		.114 FPS/IN.
VERT. VIBRATION	32		.057 FPS/IN.

* FOR UNLOADED ROTOR & =3°, 2.36 FOR SOFT HUB

** FOR UNLOADED ROTOR, 0.67 FOR =3°, AND 0.68 FOR SOFT HUB

NOTE: PITCH LINK = INBOARD TORSION

SIGN CONVENTION

DRAG LINK & PITCH LINK: TENSION IS POSITIVE
FLAPWISE BENDING: COMPRESSION UPPER SURFACE IS POSITIVE
CHORDWISE BENDING: COMPRESSION L.E. IS POSITIVE
TORSION: NOSE UP ACTION LOAD IS POSITIVE
ALL NOSE UP PITCH ANGLES ARE POSITIVE
ALL RIGHT SIDE DOWN ROLL ANGLES ARE POSITIVE

TABLE 8 CALIBRATION FACTORS FOR MEASUREMENT OF DYNAMIC LOADS - CONFIGURATIONS F, G, AND H
TEST DATES: DEC. 19, 1962 - DEC. 20, 1962

ITEM	TRACE NO.	STATIC ZERO (INCHES) RUN 31	STATIC ZERO (INCHES) RUN 32	CALIBRATION FACTOR	
#1 - Drag Link	1-3	5.64	5.74	103.200	lbs/in
#2 - Drag Link	1-4	5.33	5.47	104.403	lbs/in
#3 - Drag Link	1-5	5.17	5.16	105.606	lbs/in
#1 - Inbd. Flap	1-10				
#2 - Inbd. Flap	1-11	2.84	3.15	1061	in-lbs/in
#3 - Inbd. Flap	1-12	2.58	2.91	1038	in-lbs/in
#1 - Pitch Link	1-13	2.08	2.20	172.807	lbs/in
#2 - Pitch Link	1-14	1.67	1.90	169.546	lbs/in
#3 - Pitch Link	1-15	1.75	1.62	181.610	lbs/in
#1 - Mid Chord	2-6	3.84	4.56	2060	in-lbs/in
#1 - Mid Flap	2-8	3.26	3.76	430	in-lbs/in
#1 - Mid Torsion	2-10	2.68	3.07	1716	in-lbs/in
#1 - Outbd. Flap	2-12	2.17	2.43	166.7	in-lbs/in
Model Attitude	2-11	2.40	2.57	6.7	deg/in
Collective Pitch	2-13	1.80	2.00	4.9	deg/in
#1 - Cyclic Pitch	1-7	4.11	4.35	23	deg/in
#2 - Cyclic Pitch	1-8	3.90	4.04	23	deg/in
#3 - Cyclic Pitch	1-9	3.42	3.85	23	deg/in
Gyro Roll Pos.	2-3	4.89	5.20	3.45	deg/in
Gyro Pitch Pos.	2-5	4.11	4.84	5.24	deg/in
Thrust	2-17	.61	.65	293	lbs/in
Drag	2-15	1.14	1.28	25.4	lbs/in
Roll Moment	2-7	2.61	4.08		
Pitch Moment	2-9	2.96	3.43		
Lat. Vibration	2-14	1.54	1.65	2.7	$\frac{FPS^2}{G}$/in
Long. Vibration	2-16	.94	.96	2.5	$\frac{FPS^2}{G}$/in
Vert. Vibration	1-16	.95	2.47	2.5	$\frac{FPS^2}{G}$/in

SIGN CONVENTION

DRAG LINK & PITCH LINK: TENSION IS POSITIVE
FLAPWISE BENDING: COMPRESSION UPPER SURFACE IS POSITIVE
CHORDWISE BENDING: COMPRESSION L. E. IS POSITIVE
TORSION: NOSE UP ACTION LOAD IS POSITIVE
ALL NOSE UP PITCH ANGLES ARE POSITIVE
ALL RIGHT SIDE DOWN ROLL ANGLES ARE POSITIVE

TABLE 9 CALIBRATION FACTORS FOR MEASUREMENT OF DYNAMIC LOADS - CONFIGURATIONS J AND K
TEST DATES: MAY 7 & 8, 1963

ITEM	TRACE NO.	STATIC ZERO (INCHES) RUN 33	STATIC ZERO (INCHES) RUN 34	STATIC ZERO (INCHES) RUN 35	CALIBRATION FACTOR	
#1 - DRAG LINK	1-3	5.91	5.83	5.79	102.238	LBS/IN.
#2 - DRAG LINK	1-4	5.54	5.48	5.49	108.252	LBS/IN.
#3 - DRAG LINK	1-5	5.33	5.38	5.13	107.049	LBS/IN.
#1 - INBD. FLAP	1-10					
#2 - INBD. FLAP	1-11	3.23	3.24	3.24	1061	IN-LBS/IN.
#3 - INBD. FLAP	1-12	2.97	3.01	3.00	1061	IN-LBS/IN.
#1 - PITCH LINK	1-13	2.29	2.12	2.28	174.654	LBS/IN.
#2 - PITCH LINK	1-14	2.01	1.92	2.02	174.654	LBS/IN.
#3 - PITCH LINK	1-15	1.77	1.77	1.74	174.654	LBS/IN.
#1 - MID CHORD	2-6	4.12	4.21	4.11	2060	IN-LBS/IN.
#1 - MID FLAP	2-8	3.49	3.49	3.72	426	IN-LBS/IN.
#1 - MID TORSION	2-10	2.96	2.94	3.14	1182	IN-LBS/IN.
#1 - OUTBD. FLAP	2-12	2.05	2.31	2.23	156	IN-LBS/IN.
MODEL ATTITUDE	2-11	2.49	2.53	2.50	6.7	DEG/IN.
COLLECTIVE PITCH	2-13	1.81	1.78	1.97	4.9	DEG/IN.
#1 - CYCLIC PITCH	1-7	4.41	4.39	4.44	14.0	DEG/IN.
#2 - CYCLIC PITCH	1-8	4.17	4.09	4.06	12.6	DEG/IN.
#3 - CYCLIC PITCH	1-9	3.86	4.03	3.72	15.2	DEG/IN.
GYRO ROLL POS.	2-3	5.20	5.00	5.13	3.45	DEG/IN.
GYRO PITCH POS.	2-5	4.62	4.71	4.80	5.24	DEG/IN.
THRUST	2-17	.62	.62	.62		LBS/IN.
DRAG	2-15	1.23	1.14	1.32	25.4	LBS/IN.
ROLL MOMENT	2-7	3.80	3.77	3.72		
PITCH MOMENT	2-9	3.18	3.17	3.14		
LAT. VIBRATION	2-14	1.60	1.59	1.66	2.7	$\frac{ft/sec^2}{G}$/IN.
LONG. VIBRATION	2-16	.99	.99	1.07	2.5	$\frac{ft/sec^2}{G}$/IN.
VERT. VIBRATION	1-16	.91	.90	.91	2.5	$\frac{ft/sec^2}{G}$/IN.

SIGN CONVENTION

DRAG LINK & PITCH LINK: TENSION IS POSITIVE
FLAPWISE BENDING: COMPRESSION UPPER SURFACE IS POSITIVE
CHORDWISE BENDING: COMPRESSION L.E. IS POSITIVE
TORSION: NOSE UP ACTION LOAD IS POSITIVE
ALL NOSE UP PITCH ANGLES ARE POSITIVE
ALL RIGHT SIDE DOWN ROLL ANGLES ARE POSITIVE

TABLE 10 CALIBRATION FACTORS FOR MEASUREMENT OF DYNAMIC LOADS - CONFIGURATIONS L AND M
TEST DATES: MAY 14 & 15, 1963

TABLE 11.1 CONFIGURATION A

V_H = 0 MPH ITEM	#1721 OSCILLOGRAPH RECORD					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link	7	3.33	2.98	3.16	0.35	- 272	104	lb	
#2 - Drag Link	8	1.86	1.55	1.71	0.31	- 734	114	lb	
#3 - Drag Link	9	3.60	3.23	3.42	0.37	0	106	lb	
#1 - Inbd. Flap	10	3.08	2.84	2.96	0.61				
#2 - Inbd. Flap	11	3.12	2.84	2.98	0.[illegible]	184	867	in-lb	
#3 - Inbd. Flap	12	2.14	1.92	2.03	0.22	-479	203	in-lb	
#1 - Pitch Link	13	2.90	2.82	2.86	0.08	- 86	11	lb	
#2 - Pitch Link									
#3 - Pitch Link									
#1 - Mid Chord	20	3.93	3.76	3.85	0.17	1260	340	in-lb	
#1 - Mid Flap	22	4.48	4.15	4.31	0.33	147	110	in-lb	
#1 - Mid Torsion	24			3.52		- 26		in-lb	
#1 - Outbd. Flap	26	4.81	4.48	4.65	0.33	276	48	in-lb	
Model Attitude	27			2.32		- 1.3		deg	
Collective Pitch	29			2.85		15.5		deg	
#1 - Cyclic Pitch	16			2.15		11.2		deg	
#2 - Cyclic Pitch	17			1.67		11.3		deg	
#3 - Cyclic Pitch	18			1.32		10.9		deg	
Gyro Roll Pos.	19			4.74		- 1.1		deg	
Gyro Pitch Pos.	21			4.13		- 0.5		deg	
Thrust	33			2.12				lb	
Drag	31			1.33		12		lb	
Roll Moment	23			2.62		- 406		lb	
Pitch Moment	25			3.71		327		lb	
Lat. Vibration	28	2.33	1.78	2.06	0.55	0.352	0.094	fps	
Long. Vibration	30	1.62	1.40	1.51	0.22	0.172	0.085	fps	
Vert. Vibration	32	1.01	0.75	0.88	0.26	0.050	0.015	fps	

TABLE 11.2 CONFIGURATION A

ITEM	#1742 OSCILLOGRAPH RECORD					REDUCED DATA				μ = .81 V_H = 25 MPH
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.	COMMENTS
φ1 - Drag Link	7	3.69	3.04	3.37	0.65	-210	192	lb		Max fwd at φ = 116°
φ2 - Drag Link	8	2.32	1.84	2.08	0.48	-598	176	lb		Max fwd at φ = 109°
φ3 - Drag Link	9	4.15	3.48	3.82	0.67	114	192	lb		Max fwd at φ = 125°
φ1 - Inbd. Flap	10									
φ2 - Inbd. Flap	11	3.33	2.14	2.74	1.19	-105	1135	in-lb		Max up at φ = 223°
φ3 - Inbd. Flap	12	2.56	1.44	2.00	1.12	-507	1032	in-lb		Max up at φ = 224°
φ1 - Pitch Link	13	2.71	2.39	2.55	0.32	- 44	43	lb		Max nu at φ = 24°
φ2 - Pitch Link	14									
φ3 - Pitch Link	15									
φ1 - Mid Chord	20	4.06	3.75	3.91	0.31	-1140	620	in-lb		Max fwd at φ = 116°
φ1 - Mid Flap	22	4.61	3.62	4.12	0.99	84	331	in-lb		Max up at φ = 150°
φ1 - Mid Torsion	24	3.34	3.28	3.31	0.06	-13	79	in-lb		
φ1 - Outbd. Flap	26	5.51	4.55	5.03	0.96	331	138	in-lb		Max up at ψ = 180°
Model Attitude	27			1.83		-7.8		deg		
Collective Pitch	29			2.26		8.2		deg		
φ1 - Cyclic Pitch	16			1.53		4.7		deg		
φ2 - Cyclic Pitch	17			1.10		4.2		deg		
φ3 - Cyclic Pitch	18			1.00		7.1		deg		
Gyro Roll Pos.	19			4.80		-0.5		deg		
Gyro Pitch Pos.	21			4.11		-0.7		deg		
Thrust	33			1.27		254		lb		
Drag	31			1.30		10		lb		
Roll Moment	23			2.25		-702		in-lb		
Pitch Moment	25			6.46		1592		in-lb		
Lat. Vibration	28	2.20	1.93	2.07	0.27	0.353	0.046	fps		
Long. Vibration	30	1.64	1.36	1.50	0.28	0.171	0.032	fps		
Vert. Vibration	32	1.04	0.70	0.87	0.34	0.050	0.019	fps		

TABLE 11.3 CONFIGURATION A

n = 1.06 V_M = 25 MPH ITEM	#1806 OSCILLOGRAPH RECORD					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link	7	3.85	3.01	3.43	0.84	-192	249	lb	
#2 - Drag Link	8	3.16	2.46	2.81	0.70	-330	257	lb	
#3 - Drag Link	9	3.29	2.50	2.90	0.79	-149	226	lb	
#1 - Inbd. Flap	10								
#2 - Inbd. Flap	11	3.12	2.86	2.99	0.26	134	248	in-lb	
#3 - Inbd. Flap	12	2.51	2.21	2.36	0.30	-175	276	in-lb	
#1 - Pitch Link	13	2.79	2.50	2.65	0.29	- 58	39	lb	
#2 - Pitch Link	14	3.48	3.21	3.35	0.27	-199	38	lb	
#3 - Pitch Link	15	1.33	1.04	1.19	0.29				
#1 - Mid Chord	20	4.01	3.67	3.84	0.34	-1280	680	in-lb	
#1 - Mid Flap	22	4.45	3.82	4.14	0.64	90	214	in-lb	
#1 - Mid Torsion	24	3.33	3.26	3.30	0.07	0	92	in-lb	
#1 - Outbd. Flap	26	4.15	3.07	3.61	1.08	127	156	in-lb	
Model Attitude	27			2.28		-1.7		deg	
Collective Pitch	29			2.19		7.3		deg	
#1 - Cyclic Pitch	16								
#2 - Cyclic Pitch	17								
#3 - Cyclic Pitch	18	1.04	0.74	0.89	0.30	5.8	3.5	deg	
Gyro Roll Pos.	19								
Gyro Pitch Pos.	21			3.85		-3.1		deg	
Thrust	33			1.47		332		lb	
Drag	31			1.10		-6		lb	
Roll Moment	23			3.71		57		in-lb	
Pitch Moment	25			2.45		-253		in-lb	
Lat. Vibration	28	2.27	1.86	2.07	0.41	0.353	0.070	fps	
Long. Vibration	30	1.56	1.35	2.46	0.21	0.282	0.024	fps	
Vert. Vibration	32	1.09	0.61	0.85	0.48	0.050	0.027	fps	

TABLE 11.4 CONFIGURATION A

ITEM	#1787 OSCILLOGRAPH RECORD					REDUCED DATA				n = 1.0 V_H = 50 MPH
	Tr. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.	COMMENTS
∅1 - Drag Link ∅2 - Drag Link ∅3 - Drag Link	7 8 9	3.79 3.22 3.34	3.01 2.66 2.66	3.39 2.94 3.00	0.78 0.56 0.68	-204 -283 -120	231 206 194	lb lb lb		Max fwd at ∅ = 180° Max fwd at ∅ = 174° Max fwd at ∅ = 178°
∅1 - Inbd. Flap ∅2 - Inbd. Flap ∅3 - Inbd. Flap	10 11 12	 3.10 2.64	 3.00 2.41	 3.05 2.53	 0.10 0.23	 191 -18	 95 212	 in-lb in-lb		
∅1 - Pitch Link ∅2 - Pitch Link ∅3 - Pitch Link	13 14 15	2.76 3.50 1.05	2.46 3.20 0.70	2.61 3.35 0.88	0.30 0.30 0.35	-52 -199	40 42	lb lb		Max nu at ∅ = 231° Max nu at ∅ = 251° Max nu at ∅ = 258°
∅1 - Mid Chord ∅1 - Mid Flap ∅1 - Mid Torsion ∅1 - Outbd. Flap	20 22 24 26	4.10 4.53 3.34 3.98	3.79 3.74 3.26 2.62	3.95 4.14 3.30 2.80	0.31 0.79 0.08 0.36	-1060 90 0 10	620 264 105 52	in-lb in-lb in-lb in-lb		Max fwd at ∅ = 180° Max flap at ∅ = 301° Max flap at ∅ = 307°
Model Attitude Collective Pitch ∅1 - Cyclic Pitch ∅2 - Cyclic Pitch ∅3 - Cyclic Pitch	27 29 16 17 18	 1.56 1.22 1.01	 1.31 1.01 0.70	2.16 2.09 1.44 1.12 0.86	 0.25 0.21 0.31	-3.4 6.1 3.7 4.4 5.4	 2.7 2.6 3.7	deg deg deg deg deg		Max [illegible] at ∅ = 30° Max [illegible] at ∅ = 24° Max [illegible] at ∅ = 351°
Gyro Roll Pos. Gyro Pitch Pos.	19 21			4.65 3.91		-1.9 -2.5		deg deg		
Thrust Drag Roll Moment Pitch Moment	33 31 23 25			1.42 1.13 3.59 2.94		312 -4 -5 -27		lb lb in-lb in-lb		
Lat. Vibration Long. Vibration Vert. Vibration	28 30 32	2.39 1.61 1.16	1.78 1.38 0.56	2.09 1.50 0.86	0.61 0.23 0.60	0.358 0.171 0.049	0.104 0.026 0.034	fps fps fps		

TABLE 11.5 CONFIGURATION A

$n = .51$ $V_M = 50$ MPH ITEM	#1788 OSCILLOGRAPH RECORD					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link	7	3.74	3.32	3.53	0.42	-163	124	lb	
#2 - Drag Link	8	3.09	2.69	2.89	0.40	-301	147	lb	
#3 - Drag Link	9	3.32	2.98	3.15	0.34	- 77		lb	
#1 - Inbd. Flap	10								
#2 - Inbd. Flap	11	3.32	2.52	2.92	0.80	67	763	in-lb	
#3 - Inbd. Flap	12	2.81	2.14	2.43	0.67	- 64	617	in-lb	
#1 - Pitch Link	13	2.71	2.53	2.62	0.18	- 54	-24	lb	
#2 - Pitch Link	14	3.79	3.56	-3.68	0.23	-245	-32	lb	
#3 - Pitch Link	15	0.78	0.64	0.71	0.14	No calibration			
#1 - Mid Chord	20	4.06	3.89	3.97	0.17	-1020	340	in-lb	
#1 - Mid Flap	22	4.41	3.78	4.10	0.63	77	210	in-lb	
#1 - Mid Torsion	24	3.33	3.31	3.32	0.02	- 26	-26	in-lb	
#1 - Outbd. Flap	26	3.97	3.26	3.60	0.68	125	98	in-lb	
Model Attitude	27	1.07	1.07	1.07	0	- 17.9	0	deg	
Collective Pitch	29	2.10	2.09	2.10	0.01	6.2	0.12	deg	
#1 - Cyclic Pitch	16								
#2 - Cyclic Pitch	17			Instrumentation Malfunction					
#3 - Cyclic Pitch	18								
Gyro Roll Pos.	19	4.77	4.75	4.76	0.02	- 0.9	0.2	deg	
Gyro Pitch Pos.	21	4.11	4.09	4.10	0.02	- 0.8	0.2	deg	
Thrust	33	1.03	1.01	1.03	0.02	160	8	lb	
Drag	31	1.12	1.12	1.12	0	- 5	0	lb	
Roll Moment	23	3.71	3.71	3.71	0	57	0	in-lb	
Pitch Moment	25	3.21	3.21	3.21	0	97	0	in-lb	
Lat. Vibration	28	2.21	1.95	2.08	0.26	0.356	0.044	fps	
Long. Vibration	30	1.66	1.38	1.52	0.28	0.173	0.032	fps	
Vert. Vibration	32	1.05	0.69	0.87	0.36	0.050	0.021	fps	

n = 1.45 V_M = 50 MPH ITEM	#1789 OSCILLOGRAPH RECORD					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link	7	4.03	2.82	3.43	1.21	- 192	358	lb	
#2 - Drag Link	8	3.27	2.33	2.80	0.94	- 334	345	lb	
#3 - Drag Link	9	3.58	2.32	2.95	1.26	- 135	360	lb	
#1 - Inbd. Flap	10								
#2 - Inbd. Flap	11	3.32	3.16	3.24	0.16	372	153	in-lb	
#3 - Inbd. Flap	12	2.83	2.66	2.75	0.17	184	157	in-lb	
#1 - Pitch Link	13	2.69	2.41	2.55	0.28	- 44	-38	lb	
#2 - Pitch Link	14	3.82	3.53	3.68	0.29	- 245	-41	lb	
#3 - Pitch Link	15	0.68	0.41	0.55	0.27	No Calibration			
#1 - Mid Chord	20	4.16	3.67	3.92	0.49	-1120	980	in-lb	
#1 - Mid Flap	22	4.47	3.93	4.20	0.54	110	180	in-lb	
#1 - Mid Torsion	24	3.35	3.29	3.32	0.06	- 26	-79	in-lb	
#1 - Outbd. Flap	26	3.81	2.59	3.20	1.22	68	176	in-lb	
Model Attitude	27	2.82	2.82	2.82	0	5.5	0	deg	
Collective Pitch	29	2.10	2.09	2.10	0.01	6.2	0.12	deg	
#1 - Cyclic Pitch	16	1.63	1.25	1.44	0.38	3.7	4.0	deg	
#2 - Cyclic Pitch	17	1.26	1.02	1.14	0.24	4.7	3.0	deg	
#3 - Cyclic Pitch	18	1.08	0.68	0.88	0.40	5.7	4.7	deg	
Gyro Roll Pos.	19	4.67	4.65	4.66	0.02	- 1.9	0.2	deg	
Gyro Pitch Pos.	21	3.87	3.85	3.86	0.02	- 2.9	0.2	deg	
Thrust	33	1.79	1.77	1.78	0.02	452	8	lb	
Drag	31	1.97	1.95	1.96	0.02	62	2	lb	
Roll Moment	23	3.61	3.60	3.61	0.01	5	5	in-lb	
Pitch Moment	25	3.11	3.09	3.10	0.02	46	9	in-lb	
Lat. Vibration	28	2.38	1.77	2.07	0.61	0.354	0.104	fps	
Long. Vibration	30	1.61	1.35	1.48	0.26	0.169	0.030	fps	
Vert. Vibration	32	1.11	0.61	0.86	0.50	0.049	0.029	fps	

TABLE 11.7 CONFIGURATION A

n = 1.55 V_M = 50 MPH ITEM	#1790 OSCILLOGRAPH RECORD					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link	7	4.06	2.86	3.46	1.20	-184	355	lb	
#2 - Drag Link	8	3.28	2.34	2.81	0.94	-330	345	lb	
#3 - Drag Link	9	3.70	2.38	3.04	1.32	-109	378	lb	
#1 - Inbd. Flap	10								
#2 - Inbd. Flap	11	3.33	3.19	3.26	0.14	391	133	in-lb	
#3 - Inbd. Flap	12	2.83	2.69	2.76	0.14	193	129	in-lb	
#1 - Pitch Link	13	2.71	2.47	2.59	0.24	- 50	- 32	lb	
#2 - Pitch Link	14	3.86	3.60	3.73	0.26	-252	- 36	lb	
#3 - Pitch Link	15	0.82	0.32	0.57	0.50	No	calibration		
#1 - Mid Chord	20	4.15	3.67	3.91	0.48	-1120	960	in-lb	
#1 - Mid Flap	22	4.45	3.97	4.21	0.48	114	160	in-lb	
#1 - Mid Torsion	24	3.36	3.30	3.33	0.06	- 39	- 79	in-lb	
#1 - Outbd. Flap	26	3.71	2.53	3.12	1.18	56	170	in-lb	
Model Attitude	27	2.95	2.95	2.95	0	7.2	0	deg	
Collective Pitch	29	2.11	2.10	2.11	0.01	6.3	0.12	deg	
#1 - Cyclic Pitch	16	1.65	1.22	1.45	0.43	3.8	4.6	deg	
#2 - Cyclic Pitch	17	1.27	1.05	1.16	0.22	4.9	2.8	deg	
#3 - Cyclic Pitch	18	1.08	0.67	0.88	0.41	5.7	4.8	deg	
Gyro Roll Pos.	19	4.19	4.17	4.18	0.02	- 6.6	0.2	deg	
Gyro Pitch Pos.	21	3.87	3.86	3.87	0.01	- 2.9	0.1	deg	
Thrust	33	1.86	1.85	1.86	0.01	484	4	lb	
Drag	31	2.19	2.17	2.18	0.02	80	2	lb	
Roll Moment	23	3.55	3.54	3.55	0.01	- 26	5	in-lb	
Pitch Moment	25	3.12	3.11	3.12	0.01	55	5	in-lb	
Lat. Vibration	28	2.32	1.84	2.08	0.49	0.356	0.084	fps	
Long. Vibration	30	1.62	1.32	1.47	0.30	0.168	0.034	fps	
Vert. Vibration	32	1.11	0.64	0.88	0.47	0.050	0.027	fps	

TABLE 11.8. CONFIGURATION A

ITEM	#1792 OSCILLOGRAPH RECORD					REDUCED DATA				n = .88 V_M = 106 MPH
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.	COMMENTS
ϕ1 - Drag Link	7	3.96	2.97	3.47	0.99	-181	293	lb		Max fwd at ψ = 118°
ϕ2 - Drag Link	8	3.20	2.46	2.83	0.74	-323	272	lb		Max fwd at ψ = 124°
ϕ3 - Drag Link	9	3.56	2.56	3.06	1.00	-103	286	lb		Max fwd at ψ = 124°
ϕ1 - Inbd. Flap	10									
ϕ2 - Inbd. Flap	11	3.08	2.97	3.00	0.16	143	153	in-lb		
ϕ3 - Inbd. Flap	12	2.60	2.41	2.51	0.19	- 37	175	in-lb		
ϕ1 - Pitch Link	13	2.90	2.50	2.70	0.40	- 64	54	lb		Max nu at ψ = 231°
ϕ2 - Pitch Link	14	3.92	3.56	3.74	0.36	-253	50	lb		Max nu at ψ = 212°
ϕ3 - Pitch Link	15									
ϕ1 - Mid Chord	20	4.17	3.84	4.00	0.33	-960	660	in-lb		Max fwd at ψ = 125°
ϕ1 - Mid Flap	22	4.64	3.73	4.19	0.91	107	304	in-lb		Max flap at ψ = 294°
ϕ1 - Mid Torsion	24	3.34	3.26	3.30	0.08	0	105	in-lb		
ϕ1 - Outbd. Flap	26	4.02	2.65	3.34	1.37	88	[illegible]	in-lb		Max flap at ψ = 307°
Model Attitude	27			1.86		-7.4		deg		
Collective Pitch	29			2.20		7.4		deg		
ϕ1 - Cyclic Pitch	16	1.73	1.23	1.43	0.40	3.6	4.2	deg		Max at ψ = 351°
ϕ2 - Cyclic Pitch	17	1.35	1.04	1.20	0.31	5.4	3.9	deg		Max at ψ = 352°
ϕ3 - Cyclic Pitch	18	1.20	0.71	0.96	0.49	5.4	5.8	deg		Max at ψ = 325°
Gyro Roll Pos.	19			4.76		-0.9				
Gyro Pitch Pos.	21			3.81		-3.4				
Thrust	33			1.33		277		lb		
Drag	31			1.11		-6		lb		
Roll Moment	23			3.46		-73		in-lb		
Pitch Moment	25			2.65		-69		in-lb		
Lat. Vibration	28	2.34	1.71	2.03	0.63	0.348	0.108	fps		
Long. Vibration	30	1.65	1.33	1.49	0.32	0.169	0.036	fps		
Vert. Vibration	32	1.17	0.54	0.86	0.63	0.049	0.036	fps		

TABLE 11.9 CONFIGURATION A

n = .5 V_H = 106 MPH ITEM	#1793 OSCILLOGRAPH RECORD					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link	7	3.76	3.26	3.51	0.50	-109	148	lb	
#2 - Drag Link	8	3.07	2.67	2.87	0.40	-308	147	lb	
#3 - Drag Link	9	3.43	2.78	3.11	0.65	- 89	186	lb	
#1 - Inbd. Flap	10								
#2 - Inbd. Flap	11	3.22	2.64	2.93	0.58	76	553	in-lb	
#3 - Inbd. Flap	12	2.69	2.25	2.47	0.44	- 74	405	in-lb	
#1 - Pitch Link	13	2.98	2.54	2.76	0.44	- 72	-59	lb	
#2 - Pitch Link	14	3.92	3.62	3.77	0.30	-258	-42	lb	
#3 - Pitch Link	15	1.18	0.53	0.86	0.65	No calibration			
#1 - Mid Chord	20	4.14	3.96	4.05	0.18	-860	360	in-lb	
#1 - Mid Flap	22	4.53	3.73	4.13	0.80	87	267	in-lb	
#1 - Mid Torsion	24	3.35	3.28	3.32	0.07	- 26	-92	in-lb	
#1 - Outbd. Flap	26	4.04	2.83	3.44	1.21	102	174	in-lb	
Model Attitude	27	1.47	1.47	1.47	0	-12.6	0	deg	
Collective Pitch	29	2.23	2.22	2.23	0.01	7.8	0.12	deg	
#1 - Cyclic Pitch	16	1.61	1.35	1.48	0.26	4.1	2.8	deg	
#2 - Cyclic Pitch	17	1.26	1.08	1.17	0.18	5.0	2.3	deg	
#3 - Cyclic Pitch	18	1.11	0.79	0.95	0.32	6.5	3.8	deg	
Gyro Roll Pos.	19	4.81	4.78	4.80	0.03	-0.5	0.3	deg	
Gyro Pitch Pos.	21	3.94	3.92	3.93	0.02	-2.3	0.2	deg	
Thrust	33	1.03	1.01	1.02	0.02	156	8	lb	
Drag	31	1.12	1.12	1.12	0	- 5	0	lb	
Roll Moment	23	3.55	3.51	3.53	0.04	- 36	21	in-lb	
Pitch Moment	25	3.27	3.23	3.25	0.04	115	18	in-lb	
Lat. Vibration	28	2.30	1.97	2.14	0.33	0.366	0.056	fps	
Long. Vibration	30	1.71	1.32	1.52	0.39	0.173	0.044	fps	
Vert. Vibration	32	1.11	0.52	0.82	0.59	0.047	0.034	fps	

TABLE 11.10 CONFIGURATION A

n = 1.46 V_M = 106 MPH ITEM	#1794 OSCILLOGRAPH RECORD					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link	7	4.17	2.70	3.44	1.47	189	435	lb	
#2 - Drag Link	8	3.37	2.16	2.77	1.21	-345	444	lb	
#3 - Drag Link	9	3.77	2.32	3.05	1.45	-106	415	lb	
#1 - Inbd. Flap	10								
#2 - Inbd. Flap	11	3.26	3.17	3.22	0.09	353	86	in-lb	
#3 - Inbd. Flap	12	2.85	2.55	2.70	0.30	138	276	in-lb	
#1 - Pitch Link	13	2.84	2.46	2.65	0.38	- 58	-51	lb	
#2 - Pitch Link	14	3.93	3.55	3.74	0.38	-253	-53	lb	
#3 - Pitch Link	15	1.33	0.39	0.86	0.94	No calibration			
#1 - Mid Chord	20	4.21	3.65	3.93	0.56	-1100	1120	in-lb	
#1 - Mid Flap	22	4.80	3.70	4.25	1.10	127	367	in-lb	
#1 - Mid Torsion	24	3.39	3.27	3.33	0.12	- 39	-157	in-lb	
#1 - Outbd. Flap	26	3.84	2.28	3.06	1.56	48	225	in-lb	
Model Attitude	27	2.30	2.30	2.30	0	-1.5	0	deg	
Collective Pitch	29	2.21	2.21	2.21	0	7.6	0	deg	
#1 - Cyclic Pitch	16	1.88	1.15	1.52	0.73	4.6	7.7	deg	
#2 - Cyclic Pitch	17	1.43	1.03	1.23	0.40	5.8	5.0	deg	
#3 - Cyclic Pitch	18	1.28	0.65	0.97	0.63	6.6	7.4	deg	
Gyro Roll Pos.	19	4.81	4.79	4.80	0.02	-0.5	0.2	deg	
Gyro Pitch Pos.	21	3.75	3.71	3.73	0.04	-4.1	0.4	deg	
Thrust	33	1.79	1.78	1.79	0.01	456	4	lb	
Drag	31	1.52	1.51	1.52	0.01	27	1	lb	
Roll Moment	23	3.58	3.57	3.58	0.01	- 10	5	in-lb	
Pitch Moment	25	2.97	2.93	2.95	0.04	- 23	18	in-lb	
Lat. Vibration	28	2.26	1.79	2.03	0.47	0.347	0.080	fps	
Long. Vibration	30	1.58	1.22	1.40	0.36	0.160	0.041	fps	
Vert. Vibration	32	1.21	0.47	0.84	0.74	0.048	0.048	fps	

TABLE 11.11 CONFIGURATION A

n = 1.89 V_H = 106 MPH ITEM	#1795 OSCILLOGRAPH RECORD					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link	7	4.59	2.03	3.31	2.56	-228	758	lb	
#2 - Drag Link	8	3.59	1.50	2.55	2.09	-426	767	lb	
#3 - Drag Link	9	5.20	-0.14	2.53	5.34	-255	1527	lb	
#1 - Inbd. Flap	10								
#2 - Inbd. Flap	11	3.46	3.10	3.28	0.36	410	343	in-lb	
#3 - Inbd. Flap	12	2.95	2.62	2.79	0.33	221	304	in-lb	
#1 - Pitch Link	13	2.88	2.43	2.66	0.45	- 59	- 60	lb	
#2 - Pitch Link	14								
#3 - Pitch Link	15	1.59	0.17	0.88	1.42	No	calibration		
#1 - Mid Chord	20	4.52	3.28	3.90	1.24	-1160	2480	in-lb	
#1 - Mid Flap	22	4.90	3.74	4.32	1.16	150	337	in-lb	
#1 - Mid Torsion	24	3.40	3.26	3.33	0.14	- 39	-163	in-lb	
#1 - Outbd. Flap	26	3.87	2.24	3.06	1.63	48	235	in-lb	
Model Attitude	27	2.61	2.61	2.61		2.7	0	deg	
Collective Pitch	29	2.22	2.21	2.22	0.01	7.7	0.12	deg	
#1 - Cyclic Pitch	16	1.95	1.10	1.53	0.85	4.7	9.0	deg	
#2 - Cyclic Pitch	17	1.50	1.12	1.31	0.38	6.8	4.8	deg	
#3 - Cyclic Pitch	18	1.33	0.61	0.97	0.72	6.7	8.5	deg	
Gyro Roll Pos.	19	4.81	4.79	4.80	0.02	-0.5	0.2	deg	
Gyro Pitch Pos.	21	3.69	3.67	3.68	0.02	-4.6	0.2	deg	
Thrust	33	2.15	2.11	2.13	0.04	589	16	lb	
Drag	31	2.11	2.10	2.11	0.01	74	1	lb	
Roll Moment	23	3.52	3.49	3.51	0.03	- 47	16	in-lb	
Pitch Moment	25	3.23	3.20	3.22	0.03	101	14	in-lb	
Lat. Vibration	28	2.42	1.68	2.05	0.74	0.351	0.127	fps	
Long. Vibration	30	1.74	1.28	1.51	0.46	0.172	0.052	fps	
Vert. Vibration	32	1.29	0.47	0.89	0.80	0.051	0.046	fps	

TABLE 12.1 CONFIGURATION B

n = .9 V_M = 0 MPH ITEM	#1970 OSCILLOGRAPH RECORD TR. No.	MAX	MIN	AVE	2A	REDUCED DATA AVE	2A	UNITS	CYC REV.
#1 - Drag Link									
#2 - Drag Link	7	3.57	3.44	3.58	0.19	-126	67	lb	1&8
#3 - Drag Link	8	3.43	3.20	3.32	0.23	-112	68	lb	1&8
#1 - Inbd. Flap									
#2 - Inbd. Flap	14	2.34	2.23	2.31	0.05	[illegible]	59	in-lb	1
#3 - Inbd. Flap	15	1.97	1.84	1.91	0.13	265	127	in-lb	1
#1 - Pitch Link	16	0.76	0.66	0.71	0.10	- 78	14	lb	3
#2 - Pitch Link	17	0.29	0.20	0.25	0.09	-104	12	lb	3
#3 - Pitch Link	18	0.41	0.33	0.37	0.08	- 60	13	lb	3
#1 - Mid Chord	20	3.59	3.48	3.54	0.11	-1584	194	in-lb	8
#1 - Mid Flap	22	No Record							
#1 - Mid Torsion	24	3.33	3.28	3.31	0.05	15	75	in-lb	3
#1 - Outbd. Flap	26	2.33	2.16	2.25	0.17	- 74	32	in-lb	3
Model Attitude	27			2.40		- 0.1		deg	
Collective Pitch	29			2.30		8.2	.5	deg	
#1 - Cyclic Pitch	10	3.70	3.66	3.68	0.04	8.9	.46	deg	3
#2 - Cyclic Pitch	11	3.29	3.25	3.27	0.04	7.4	.46	deg	3
#3 - Cyclic Pitch	12	2.96	2.92	2.94	0.04	7.4	.49	deg	3
Gyro Roll Pos.	19			4.65		- 0.7			
Gyro Pitch Pos.	21			4.13		0.1			
Thrust	33			1.35		84		lb	
Drag	31			1.30		10		lb	
Roll Moment	23			3.48		- 21		in-lb	
Pitch Moment	25			3.11		57		in-lb	
Lat. Vibration	28	2.20	1.38		0.32		0.055	fps	1&3
Long. Vibration	30	1.57	1.33		0.24		0.027	fps	
Vert. Vibration	32	0.97	0.76		0.21		0.012	fps	

TABLE 12.2 CONFIGURATION B

ITEM	#1973 OSCILLOGRAPH RECORD					REDUCED DATA				n = .5 V_M = 25 MPH
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.	COMMENTS
ϕ1 - Drag Link										
ϕ2 - Drag Link	7	3.48	2.64	3.06	0.84	-312	297	lb	1	Max fwd at ψ ≅ 188°
ϕ3 - Drag Link	8	4.30	3.48	3.89	0.82	56	242	lb	1	Max fwd at ψ = 132°
ϕ1 - Inbd. Flap										
ϕ2 - Inbd. Flap	14	2.44	2.11	2.27	0.33	376	327	in-lb	1	Max flap at ψ ≅ 322°
ϕ3 - Inbd. Flap	15	2.18	1.80	1.99	0.38	343	372	in-lb	1	Max flap at ψ = 300°
ϕ1 - Pitch Link	16	0.87	0.59	0.73	0.28	- 75	37	lb	1&3	Max nu at ψ ≅ 89°
ϕ2 - Pitch Link	17	-.54	-.86	0.70	0.32	- 41	44	lb	1&3	Max nu at ψ ≅ 86°
ϕ3 - Pitch Link	18	1.54	1.30	1.42	0.24	105	38	lb	1&3	Max nu at ψ ≅ 71°
ϕ1 - Mid Chord	20	3.68	3.36	3.52	0.32	-1620	536	in-lb	1	Max fwd at ψ ≅ 218°
ϕ1 - Mid Flap	22	No Record								
ϕ1 - Mid Torsion	24	3.36	3.29	3.33	0.07	45	104	in-lb	6	
ϕ1 - Outbd. Flap	26	1.25	0.31	0.78	0.94	- 353	179	in-lb	1&3	Max flap at ψ ≅ 244°
Model Attitude	27			2.30		- 1.5		deg		
Collective Pitch	29			2.19		7.0		deg		
ϕ1 - Cyclic Pitch	10	3.82	3.31	3.57	0.51	7.6	5.8	deg	1	Max at ψ ≅ 9°
ϕ2 - Cyclic Pitch	11	3.40	2.92	3.16	0.48	6.1	5.6	deg	1	Max at ψ ≅ 7°
ϕ3 - Cyclic Pitch	12	3.08	2.62	2.85	0.46	6.3	5.6	deg	1	Max at ψ ≅ 351°
Gyro Roll Pos.	19			4.62		- 1.0		deg		
Gyro Pitch Pos.	21			3.90		- 2.0		deg		
Thrust	33			1.36		156		lb		
Drag	31			1.20		2		lb		
Roll Moment	23			4.70		299		in-lb		
Pitch Moment	25			3.18		82		in-lb		
Lat. Vibration	28	2.21	1.88		0.33		0.056	fps	3	
Long. Vibration	30	1.67	1.32		0.35		0.040	fps	3	
Vert. Vibration	32	1.10	0.66		0.44		0.025	fps	3	

TABLE 12.3 CONFIGURATION B

n= .7L V_H = 25 MPH ITEM	OSCILLOGRAPH RECORD					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link									
#2 - Drag Link	7	3.30	2.85	3.08	0.45	-305	159	lb	1
#3 - Drag Link	8	4.21	3.73	3.97	0.48	80	142	lb	1
#1 - Inbd. Flap									
#2 - Inbd. Flap	14	2.44	2.05	2.25	0.39	357	386	in-lb	1
#3 - Inbd. Flap	15	2.17	1.63	1.90	0.54	255	529	in-lb	1
#1 - Pitch Link	16	0.76	0.62	0.69	(14	- 81	18	lb	1&4
#2 - Pitch Link	17								
#3 - Pitch Link	18	0.70	0.60	0.6[illegible]	0.10	- 16	16	lb	1
#1 - Mid Chord	20	3.63	3.47	3.55	0.16	-1566	282	in-lb	1
#1 - Mid Flap	22	No Record							
#1 - Mid Torsion	24			3.3[illegible]		45		in-lb	
#1 - Outbd. Flap	26	1.07	0.64	0.86	0.43	- 338	82	in-lb	[illegible]
Model Attitude	27			1.15		-16.9		deg	
Collective Pitch	29			2.19		7.0		deg	
#1 - Cyclic Pitch	10	3.66	3.45	3.56	0.21	7.5	2.4	deg	1
#2 - Cyclic Pitch	11	3.28	3.06	3.17	0.22	6.2	2.6	deg	1
#3 - Cyclic Pitch	12	2.93	2.76	2.85	0.17	6.3	2.1	deg	1
Gyro Roll Pos.	19			4.68		- 0.4		deg	
Gyro Pitch Pos.	21			4.00		- 1.1		deg	
Thrust	33			1.22		234		lb	
Drag	31			1.19		1		lb	
Roll Moment	23			4.12		147		in-lb	
Pitch Moment	25			3.13		64		in-lb	
Lat. Vibration	28	2.15	1.94		0.21		0.036	fps	3
Long. Vibration	30	1.65	1.34		0.21		0.024	fps	
Vert. Vibration	32	1.07	0.71		0.36		0.021	fps	

TABLE 12.4 CONFIGURATION B

ITEM	#1977 OSCILLOGRAPH RECORD					REDUCED DATA				$n = 1.13$ $V_H = 25$ MPH
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.	COMMENTS
#1 - Drag Link										
#2 - Drag Link	7	3.65	2.43	3.04	1.22	- 318	432	lb	1	Max fwd at ψ ≈ 201°
#3 - Drag Link	8	4.38	3.16	3.77	1.22	21	360	lb	1	Max fwd at ψ ≈ 202°
#1 - Inbd. Flap										
#2 - Inbd. Flap	14	2.64	2.08	2.36	0.56	465	554	in-lb	1	Max flap at ψ ≈ 348°
#3 - Inbd. Flap	15	2.31	1.82	2.07	0.49	421	480	in-lb	1	Max flap at ψ = 338°
#1 - Pitch Link	16	0.94	0.56	0.75	0.38	- 73	50	lb	1&4	Max nu at ψ ≈ 95°
#2 - Pitch Link	17	-0.44	-0.82	0.63	0.38	- 51	52	lb	1&4	Max nu at ψ = 86°
#3 - Pitch Link	18	1.67	1.34	1.51	0.33	119	52	lb	1&4	Max nu at ψ ≈ 74°
#1 - Mid Chord	20	3.74	3.29	3.52	0.35	-1620	616	in-lb	1&2	Max fwd at ψ ≈ 212°
#1 - Mid Flap	22	No Record								
#1 - Mid Torsion	24	3.34	3.26	3.30	0.08	0	119	in-lb		
#1 - Outbd. Flap	26	1.59	0.26	0.93	1.33	- 324	253	in-lb	1&3	Max flap at ψ = 314°
Model Attitude	27			2.97		7.5		deg		
Collective Pitch	29			2.19		7.0		deg		
#1 - Cyclic Pitch	10	3.92	3.13	3.58	0.79	7.7	9.0	deg	1	Max ∢ at ψ = 12°
#2 - Cyclic Pitch	11	3.52	2.80	3.16	0.72	6.2	8.4	deg	1	Max ∢ at ψ = 14°
#3 - Cyclic Pitch	12	3.22	2.50	2.86	0.72	6.5	8.8	deg	1	Max ∢ at ψ = 358°
Gyro Roll Pos.	19			4.56		- 1.6		deg		
Gyro Pitch Pos.	21			3.80		- 2.9		deg		
Thrust	33			1.53		355		lb		
Drag	31			2.04		69		lb		
Roll Moment	23			4.72		305		in-lb		
Pitch Moment	25			3.10		54		in-lb		
Lat. Vibration	28	2.24	1.83		0.41		0.070	fps	3	
Long. Vibration	30	1.66	1.30		0.36		0.041	fps	3	
Vert. Vibration	32	1.19	0.62		0.57		0.032	fps	3	

TABLE 12.5 CONFIGURATION B

ITEM	#1979 OSCILLOGRAPH RECORD TR. No.	MAX	MIN	AVE	2A	REDUCED DATA AVE	2A	UNITS	CYC REV.	n = .97, V_H = 50 MPH COMMENTS
Ø1 - Drag Link										
Ø2 - Drag Link	7	3.44	2.84	3.14	0.61	- 283	212	lb	1	Max fwd at ψ = 175°
Ø3 - Drag Link	8	4.23	3.51	3.87	0.72	50	212	lb	1	Max fwd at ψ = 190°
Ø1 - Inbd. Flap										
Ø2 - Inbd. Flap	14	2.44	2.28	2.36	0.16	465	158	in-lb	1	Max flap at ψ = 265°
Ø3 - Inbd. Flap	15	2.19	1.92	2.06	0.27	412	265	in-lb	1	Max flap at ψ = 273°
Ø1 - Pitch Link	16	0.94	0.68	0.81	0.26	- 64	34	lb	1&4	Max mu at ψ = 82°
Ø2 - Pitch Link	17									
Ø3 - Pitch Link	18	1.56	1.38	1.47	0.18	113	28	lb	1&4	Max mu at ψ = 49°
Ø1 - Mid Chord	20	3.68	3.45	3.57	0.23	-1531	405	in-lb	1&2	Max fwd at ψ = 21°
Ø1 - Mid Flap	22	No Record								
Ø1 - Mid Torsion	24	3.35	3.28	3.32	0.07	30	104	in-lb	6	
Ø1 - Outbd. Flap	26	1.62	0.76	1.19	0.86	- 276	163	in-lb	1&3	Max flap at ψ = 314°
Model Attitude	27			2.20		- 2.8		deg		
Collective Pitch	29			2.10		5.9		deg		
Ø1 - Cyclic Pitch	10	3.54	3.05	3.30	0.49	4.6	5.6	deg	1	Max [illegible] at ψ = 359°
Ø2 - Cyclic Pitch	11	3.30	2.84	3.07	0.46	5.1	5.3	deg	1	Max [illegible] at ψ = 14°
Ø3 - Cyclic Pitch	12	2.96	2.52	2.74	0.44	5.0	5.4	deg	1	Max [illegible] at ψ = 351°
Gyro Roll Pos.	19			4.63		- 0.9		deg		
Gyro Pitch Pos.	21			3.90		- 2.0		deg		
Thrust	33			1.40		304		lb		
Drag	31			1.0		2		lb		
Roll Moment	23			4.13		150		in-lb		
Pitch Moment	25			3.10		54		in-lb		
Lat. Vibration	28	2.22	1.85		0.37		0.063	fps	3	
Long. Vibration	30	1.62	1.37		0.25		0.029	fps		
Vert. Vibration	32	1.05	0.59		0.46		0.026	fps	3	

TABLE 1[illegible].6 CONFIGURATION B

$n = .45$ V_M = 50 MPH ITEM	#1981 OSCILLOGRAPH RECORD					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link									
#2 - Drag Link	7	3.44	[illegible]	3.29	0.30	- 230	106	lb	1
#3 - Drag Link	8	4.00	[illegible]	3.84	0.32	41	94	lb	1
#1 - Inbd. Flap									
#2 - Inbd. Flap	14	2.45	2.01	2.23	0.44	337	436	in-lb	1
#3 - Inbd. Flap	15	2.11	1.71	1.91	0.40	265	39[illegible]	in-lb	1
#1 - Pitch Link	16	0.83	0.70	0.77	0.13	- 70	17	lb	4
#2 - Pitch Link	17								
#3 - Pitch Link	18	1.54	1.44	1.49	0.10	116	1[illegible]	lb	4
#1 - Mid Chord	20	3.67	3.56	3.42	0.11	-1443	194	in-lb	1
#1 - Mid Flap	22	No Record							
#1 - Mid Torsion	24			3.33		45		in-lb	
#1 - Outbd. Flap	26	1.77	1.35	1.56	0.42	- 205	80	in-lb	1&3
Model Attitude	27			1.14		- 17		deg	
Collective Pitch	29			2.11		6.0		deg	
#1 - Cyclic Pitch	10	3.34	3.22	3.28	0.12	4.3	1.4	deg	1
#2 - Cyclic Pitch	11	3.14	2.99	3.07	0.15	5.1	1.7	deg	1
#3 - Cyclic Pitch	12	2.80	2.66	2.73	0.14	4.9	1.7	deg	1
Gyro Roll Pos.	19			4.71		- 0.1		deg	
Gyro Pitch Pos.	21			4.03		- 0.8		deg	
Thrust	33			1.00		148		lb	
Drag	31			1.21		2		lb	
Roll Moment	23			3.77		55		in-lb	
Pitch Moment	25			3.05		36		in-lb	
Lat. Vibration	28	2.16	1.94		0.22		0.038	fps	
Long. Vibration	30	1.60	1.35		0.25		0.029	fps	
Vert. Vibration	32	1.02	0.70		0.3[illegible]		0.018	fps	

TABLE 12.7 CONFIGURATION B

ITEM	#1983 OSCILLOGRAPH RECORD					REDUCED DATA				$n = 1.42$ V_M = 50 MPH
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.	COMMENTS
ϕ1 - Drag Link										
ϕ2 - Drag Link	7	3.53	2.63	3.08	0.90	- 306	319	lb	1	Max fwd at ψ ≅ 175°
ϕ3 - Drag Link	8	4.40	3.44	3.92	0.96	65	283	lb	1	Max fwd at ψ ≅ 190°
ϕ1 - Inbd. Flap										
ϕ2 - Inbd. Flap	14	2.35	2.29	2.32	0.06	426	59	in-lb	1	Max flap at ψ ≅ 316°
ϕ3 - Inbd. Flap	15	2.31	1.97	2.14	0.34	490	333	in-lb	1	Max flap at ψ = 300°
ϕ1 - Pitch Link	16	0.94	0.70	0.82	0.24	- 63	32	lb	1	Max nu at ψ ≅ 76°
ϕ2 - Pitch Link	17									
ϕ3 - Pitch Link	18	1.66	1.46	1.56	0.20	127	32	lb	1	Max nu at ψ ≅ 36°
ϕ1 - Mid Chord	20	3.75	3.39	3.57	0.36	-1531	634	in-lb	1	Max fwd at ψ ≅ 212°
ϕ1 - Mid Flap	22	No Record								
ϕ1 - Mid Torsion	24			3.31			15	in-lb		
ϕ1 - Outbd. Flap	26	1.50	0.76	1.13	0.74	- 287	141	in-lb	1&3	Max flap at ψ ≅ 314°
Model Attitude	27			2.80		5.2		deg		
Collective Pitch	29			2.09		5.8		deg		
ϕ1 - Cyclic Pitch	10	3.61	2.98	3.30	0.63	4.6	7.2	deg	1	Max θ at ψ ≅ 6°
ϕ2 - Cyclic Pitch	11	3.37	2.77	3.07	0.60	5.1	7.0	deg	1	Max θ at ψ ≅ 8°
ϕ3 - Cyclic Pitch	12	3.04	2.47	2.76	0.57	5.2	7.0	deg	1	Max θ at ψ ≅ 351°
Gyro Roll Pos.	19			4.60		- 1.2		deg		
Gyro Pitch Pos.	21			3.83		- 2.6		deg		
Thrust	33			1.76		445		lb		
Drag	31			1.93		60		lb		
Roll Moment	23			4.38		216		in-lb		
Pitch Moment	25			3.34		139		in-lb		
Lat. Vibration	28	2.31	1.84		0.47		0.080	fps	3	
Long. Vibration	30	1.67	1.27		0.40		0.046	fps	3	
Vert. Vibration	32	1.08	0.62		0.46		0.026	fps	2	

TABLE 12.8 CONFIGURATION B

ITEM	#1985 OSCILLOGRAPH RECORD					REDUCED DATA				n = .91 V_M = 106 MPH
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.	COMMENTS
#1 - Drag Link										
#2 - Drag Link	7	No Record								
#3 - Drag Link	8	3.98	3.40	3.69	0.58	- 3	171	lb	1	Max fwd at ψ ≅ 216°
#1 - Inbd. Flap										
#2 - Inbd. Flap	14	-1.26	-1.43	1.35	0.17	- 535	168	in-lb	1	Max flap at ψ ≅ 221°
#3 - Inbd. Flap	15	2.10	1.89	2.00	0.21	353	206	in-lb	1	Max flap at ψ ≅ 268°
#1 - Pitch Link	16	0.84	0.54	0.65	0.30	- 86	40	lb	1&3	Max nu at ψ ≅ 58°
#2 - Pitch Link	17									
#3 - Pitch Link	18	1.15	0.92	1.04	0.23	46	36	lb	1&3	Max nu at ψ ≅ 17°
#1 - Mid Chord	20	3.76	3.52	3.64	0.24	-1408	422	in-lb	1&2	Max fwd at ψ ≅ 199°
#1 - Mid Flap	22	No Record								
#1 - Mid Torsion	24	3.35	3.28	3.32	0.07	30	104	in-lb	6	
#1 - Outbd. Flap	26	1.95	1.14	1.56	0.81	- 205	154	in-lb	1&3	Max flap at ψ ≅ 309°
Model Attitude	27			1.80		- 8.2		deg		
Collective Pitch	29			2.27		7.9		deg		
#1 - Cyclic Pitch	10	3.82	3.11	3.47	0.71	6.5	8.1	deg	1	Max x at ψ ≅ 341°
#2 - Cyclic Pitch	11	3.55	2.90	3.22	0.65	6.8	7.5	deg	1	Max x at ψ ≅ 349°
#3 - Cyclic Pitch	12	3.25	2.60	2.93	0.65	7.3	7.9	deg	1	Max x at ψ ≅ 319°
Gyro Roll Pos.	19	4.70	4.76	4.78	0.03	0.6	0.3	deg	3	
Gyro Pitch Pos.	21	3.86	3.82	3.84	0.04	- 2.5	0.4	deg	3	
Thrust	33			1.35		285		lb		
Drag	31			1.10		- 6		lb		
Roll Moment	23			3.50		- 18		in-lb		
Pitch Moment	25			3.32		132		in-lb		
Lat. Vibration	28	2.25	1.80		0.45		0.077	fps	3	
Long. Vibration	30	1.36	1.30		0.36		0.041	fps	3	
Vert. Vibration	32	1.14	0.50		0.64		0.036	fps	3	

TABLE 12.9 CONFIGURATION B

μ = .45 V_M = 106 MPH ITEM	#1987 OSCILLOGRAPH RECORD					REDUCED DATA				
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.	COMMENTS
Ø1 - Drag Link										
Ø2 - Drag Link	7	No Record								
Ø3 - Drag Link	8	3.86	3.54	3.70	0.32	0	94	lb		Poor Trace
Ø1 - Inbd. Flap										
Ø2 - Inbd. Flap	14	-1.89	-1.57	1.43	0.28	- 455	277	in-lb	1	
Ø3 - Inbd. Flap	15	2.00	1.73	1.87	0.27	285	265	in-lb	1	
Ø1 - Pitch Link	16	0.76	0.50	0.63	0.26	- 88	34	lb	1&4	
Ø2 - Pitch Link	17									
Ø3 - Pitch Link	18	1.14	0.92	1.03	0.22	44	35	lb	1&4	
Ø1 - Mid Chord	20	3.72	3.60	3.66	0.12	-1378	211	in-lb	2	
Ø1 - Mid Flap	22	No Record								
Ø1 - Mid Torsion	24	3.36	3.28	3.32	0.08	30	119	in-lb	6	
Ø1 - Outbd. Flap	26	2.07	1.50	1.77	0.57	- 165	108	in-lb	1&3	
Model Attitude	27			1.44		-13.0		deg		
Collective Pitch	29			2.26		7.8		deg		
Ø1 - Cyclic Pitch	10	3.69	3.19	3.44	0.50	6.2	5.7	deg	1	
Ø2 - Cyclic Pitch	11	3.45	2.98	3.21	0.47	6.7	5.5	deg	1	
Ø3 - Cyclic Pitch	12	3.13	2.67	2.90	0.46	6.9	5.6	deg	1	
Gyro Roll Pos.	19			4.75		0.3		deg		
Gyro Pitch Pos.	21			3.90		- 2.0		deg		
Thrust	33			0.98		140		lb		
Drag	31			1.20		2		lb		
Roll Moment	23			3.65		24		in-lb		
Pitch Moment	25			3.12		61		in-lb		
Lat. Vibration	28	2.19	1.88		0.31		0.053	fps	3	
Long. Vibration	30	1.66	1.28		0.38		0.043	fps	3	
Vert. Vibration	32	1.08	0.56		0.52		0.030	fps	3	

TABLE 13.1 CONFIGURATION C

ITEM	#2025 OSCILLOGRAPH RECORD					REDUCED DATA				$n = .94$ $V_M = 0$ MPH
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.	COMMENTS
#1 - Drag Link	6	2.90	2.79	2.85	0.11	- 149	12	lb	1	
#2 - Drag Link	7	2.57	2.42	2.50	0.15	- 161	17	lb	1	
#3 - Drag Link										
#1 - Inbd. Flap										
#2 - Inbd. Flap	14	2.16	2.08	2.12	0.08	228	80	in-lb	1	
#3 - Inbd. Flap	15	1.72	1.64	1.68	0.08	39	78	in-lb	1	
#1 - Pitch Link	16	0.66	0.56	0.61	0.10	- 91	13	lb	1&3	
#2 - Pitch Link	17	0.16	0.03	0.10	0.13	- 124	18	lb	1	
#3 - Pitch Link	18	0.48	0.37	0.43	0.11	- 50	17	lb	1	
#1 - Mid Chord	20	3.82	3.69	3.76	0.13	-1197	230	in-lb	1	
#1 - Mid Flap	22									Off the record
#1 - Mid Torsion	24			3.29		- 15		in-lb		
#1 - Outbd. Flap	26	2.36	2.10	2.23	0.26	- 78	49	in-lb	1&3	
Model Attitude	27			2.39		- 0.3		deg		
Collective Pitch	29			2.26		7.8		deg		
#1 - Cyclic Pitch	10	3.29	3.25	3.27	0.04	4.2	0.5	deg	1	
#2 - Cyclic Pitch	11	2.96	2.90	2.93	0.06	3.5	0.7	deg	1	
#3 - Cyclic Pitch	12	2.64	2.57	2.61	0.07	3.4	0.9	deg	1	
Gyro Roll Pos.	19			4.86		1.4		deg		
Gyro Pitch Pos.	21	4.18	4.14	4.16	0.04	0.4	0.4	deg		
Thrust	33			1.38		296		lb		
Drag	31			1.19		1		lb		
Roll Moment	23			3.64		21		in-lb		
Pitch Moment	25			3.04		32		in-lb		
Lat. Vibration	28	2.20	1.92		0.28		0.048	fps		No definite harmonics
Long. Vibration	30	1.55	1.38		0.17		0.019	fps		No definite harmonics
Vert. Vibration	32	1.01	0.73		0.28		0.016	fps		No definite harmonics

TABLE 13.2 CONFIGURATION C

n = 1.37 V_M = 0 MPH ITEM	#2029 OSCILLOGRAPH RECORD					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link	6	2.55	2.42	2.49	0.13	- 188	14	lb	
#2 - Drag Link	7	1.80	1.70	1.75	0.10	- 245	11	lb	
#3 - Drag Link									
#1 - Inbd. Flap									
#2 - Inbd. Flap	14	2.39	2.31	2.35	0.08	455	79	in-lb	1
#3 - Inbd. Flap	15	1.85	1.74	1.80	0.11	157	108	in-lb	1
#1 - Pitch Link	16	0.40	0.30	0.35	0.10	125	13	lb	4
#2 - Pitch Link	17								
#3 - Pitch Link	18	1.32	1.20	1.26	0.12	80	19	lb	1&4
#1 - Mid Chord	20	3 61	3.48	3.55	0.13	-1566	229	in-lb	1
#1 - Mid Flap	22								
#1 - Mid Torsion	24			3.26		- 60		in-lb	
#1 - Outbd. Flap	26	1.36	1.13	1.25	0.23	- 264	44	in-lb	3
Model Attitude	27			2.39		- 0.3		deg	
Collective Pitch	29			2.51		10.6		deg	
#1 - Cyclic Pitch	10			3.50		6.88		deg	
#2 - Cyclic Pitch	11	3.18	3.15	3.17	0.03	6.3	0.3	deg	1
#3 - Cyclic Pitch	12	2.87	2.82	2.85	0.05	6.0	0.6	deg	1
Gyro Roll Pos.	19			4.87		1.5		deg	
Gyro Pitch Pos.	21	4.19	4.16	4.18	0.03	0.5	0.3	deg	2
Thrust	33			1.72		429		lb	
Drag	31			1.24		5		lb	
Roll Moment	23			3.39		45		in-lb	
Pitch Moment									
Lat. Vibration	28	2.25	1.94		0.31		0.053	fps	3
Long. Vibration	30	1.58	1.36		0.22		0.025	fps	3
Vert. Vibration	32	0.99	0.70		0.29		0.016	fps	3

TABLE 13.3 CONFIGURATION C

ITEM	#2038 OSCILLOGRAPH RECORD					REDUCED DATA				$n = 1.04$ $V_H = 25$ MPH
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.	COMMENTS
ø1 - Drag Link	6	3.59	2.35	2.97	1.24	- 136	135	lb	1	Max fwd at $\psi \cong 304°$
ø2 - Drag Link	7	3.43	1.64	2.54	1.79	- 157	200	lb	1	Max fwd at $\psi = 317°$
ø3 - Drag Link										
ø1 - Inbd. Flap										
ø2 - Inbd. Flap	14	2.28	2.13	2.21	0.15	317	147	in-lb	1	Max flap at $\psi \cong 303°$
ø3 - Inbd. Flap	15	2.00	1.67	1.84	0.33	196	323	in-lb	1	Max flap at $\psi \cong 300°$
ø1 - Pitch Link	16	0.97	0.65	0.81	0.32	- 65	42	lb	1&3	Max mu at $\psi \cong 57°$
ø2 - Pitch Link	17									
ø3 - Pitch Link	18	1.28	1.00	1.14	0.28	61	44	lb	1&3	Max mu at $\psi \cong 53°$
ø1 - Mid Chord	20	4.16	3.70	3.93	0.46	- 898	810	in-lb	1	Max fwd at $\psi \cong 304°$
ø1 - Mid Flap	22									Not on record
ø1 - Mid Torsion	24	3.32	3.26	3.29	0.06	- 15	90	in-lb	6	
ø1 - Outbd. Flap	26	2.35	1.15	1.75	1.20	- 169	228	in-lb	1&3	Max flap at $\psi \cong 304°$
Model Attitude	27			2.27		- 1.9		deg		
Collective Pitch	29			2.32		8.5		deg		
ø1 - Cyclic Pitch	10	3.50	2.94	3.22	0.56	3.6	6.4	deg	1	Max χ at $\psi \cong 5°$
ø2 - Cyclic Pitch	11	3.15	2.54	2.85	0.61	2.6	7.1	deg	1	Max χ at $\psi \cong 4°$
ø3 - Cyclic Pitch	12	3.00	2.40	2.70	0.60	4.5	7.3	deg	1	Max χ at $\psi \cong 343°$
Gyro Roll Pos.	19			4.68		- 0.4		deg		
Gyro Pitch Pos.	21	3.88	3.83	3.86	0.05	- 2.3	0.5	deg		
Thrust	33			1.46		328		lb		
Drag	31			1.12		5		lb		
Roll Moment	23			4.00		116		in-lb		
Pitch Moment	25			3.26		111		in-lb		
Lat. Vibration	28	2.35	1.78		0.57		0.098	fps	3	
Long. Vibration	30	1.66	1.31		0.35		0.040	fps	2	
Vert. Vibration	32	1.22	0.46		0.76		0.043	fps	2	

TABLE 13.2 CONFIGURATION C

n = 1.3° V_M = 0 MPH ITEM	#2029 OSCILLOGRAPH RECORD TR. No.					REDUCED DATA AVE			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link	6	2.55	2.42	2.49	0.13	-188	14	lb	
#2 - Drag Link	7	1.80	1.70	1.75	0.10	-245	11	lb	
#3 - Drag Link									
#1 - Inbd. Flap									
#2 - Inbd. Flap	14	2.39	2.31	2.35	0.08	455	79	in-lb	1
#3 - Inbd. Flap	15	1.85	1.74	1.80	0.11	157	108	in-lb	1
#1 - Pitch Link	16	0.40	0.30	0.35	0.10	125	13	lb	4
#2 - Pitch Link	17								
#3 - Pitch Link	18	1.32	1.20	1.26	0.12	80	19	lb	1&4
#1 - Mid Chord	20	3.61	3.48	3.55	0.13	-1566	229	in-lb	1
#1 - Mid Flap	22								
#1 - Mid Torsion	24			3.26		- 60		in-lb	
#1 - Outbd. Flap	26	1.36	1.13	1.25	0.23	- 264	44	in-lb	3
Model Attitude	27			2.39		- 0.3		deg	
Collective Pitch	29			2.51		10.6		deg	
#1 - Cyclic Pitch	10			3.50		6.88		deg	
#2 - Cyclic Pitch	11	3.18	3.15	3.17	0.03	6.3	0.3	deg	1
#3 - Cyclic Pitch	12	2.87	2.82	2.85	0.05	6.0	0.6	deg	1
Gyro Roll Pos.	19			4.87		1.5		deg	
Gyro Pitch Pos.	21	4.19	4.16	4.18	0.03	0.5	0.3	deg	2
Thrust	33			1.72		429		lb	
Drag	31			1.24		5		lb	
Roll Moment	23			3.39		45		in-lb	
Pitch Moment									
Lat. Vibration	28	2.25	1.94		0.31		0.053	fps	3
Long. Vibration	30	1.58	1.36		0.22		0.025	fps	3
Vert. Vibration	32	0.99	0.70		0.29		0.016	fps	3

TABLE 13.5 CONFIGURATION C

ITEM	[illegible] OSCILLOGRAPH RECORD					REDUCED DATA				n = .7 V_H = 25 MPH
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.	COMMENTS
φ1 - Drag Link	6	3.18	2.85	3.02	0.33	- 131	36	lb	1	Max fwd at ψ ≈ 228°
φ2 - Drag Link	7	2.64	2.10	2.37	0.54	- 176	61	lb	1	Max fwd at ψ ≈ 236°
φ3 - Drag Link										
φ1 - Inbd. Flap										
φ2 - Inbd. Flap	1[illegible]	2.27	1.78	2.03	0.49	139	485	in-lb	1	Max flap at ψ ≈ 208°
φ3 - Inbd. Flap	15	1.94	1.40	1.67	0.54	29	529	in-lb	1	Max flap at ψ ≈ 235°
φ1 - Pitch Link	16	0.86	0.76	0.81	0.10	- 65	13	lb		
φ2 - Pitch Link	17									
φ3 - Pitch Link	18	1.64	1.54	1.59	0.10	132	16	lb		
φ1 - Mid Chord	20	3.88	3.65	3.79	0.23	-1109	405	in-lb	1	
φ1 - Mid Flap	22	4.39	3.92	4.16	0.47	99	141	in-lb	1&3	
φ1 - Mid Torsion	24			3.90		0				
φ1 - Outbd. Flap	26	1.80	1.36	1.58	0.44	- 201	84	in-lb	1&3	
Model Attitude	27			1.14		-17.0		deg		
Collective Pitch	29			2.12		6.2		deg		
φ1 - Cyclic Pitch	10	3.04	2.94	2.99	0.10	1.0	1.1	deg	1	Max [illegible] at ψ ≈ 38°
φ2 - Cyclic Pitch	11	2.70	2.54	2.62	0.16	- 0.1	1.9	deg	1	Max [illegible] at ψ ≈ 39°
φ3 - Cyclic Pitch	12	2.50	2.38	2.44	0.12	1.3	1.5	deg	1	Max [illegible] at ψ = 11°
Gyro Roll Pos.	19			4.76		0.4		deg		
Gyro Pitch Pos.	21			4.04		- 0.7		deg		
Thrust	33			1.18		219				
Drag	31			1.09		- 7				
Roll Moment	23			3.78		58		in-lb		
Pitch Moment	25			3.38		132		in-lb		
Lat. Vibration	28	2.18	1.95		0.23		0.039	fps	2	
Long. Vibration	30	1.59	1.35		0.24		0.027	fps	1&3	
Vert. Vibration	32	1.08	0.67		0.35		0.020	fps		

TABLE 13.6 CONFIGURATION C

ITEM	#2044 OSCILLOGRAPH RECORD					REDUCED DATA				n = 1.09 V_H = 25 MPH
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.	COMMENTS
#1 - Drag Link	6	3.46	2.57	3.02	0.89	- 131	97	lb	1	Max fwd at ψ ≅ 337°
#2 - Drag Link	7	2.92	1.65	2.37	1.27	- 176	142	lb	1	Max fwd at ψ ≅ 1°
#3 - Drag Link										
#1 - Inbd. Flap										
#2 - Inbd. Flap	14	2.39	1.92	2.03	0.47	267	465	in-lb	1	Max flap at ψ ≅ 329°
#3 - Inbd. Flap	15	2.08	1.50	1.79	0.58	147	568	in-lb	1	Max flap at ψ ≅ 320°
#1 - Pitch Link	16	1.02	0.66	0.81	0.36	- 65	48	lb	1&3	Max nu at ψ ≅ 75°
#2 - Pitch Link	17									
#3 - Pitch Link	18	1.93	1.62	1.77	0.31	165	49	lb	1&3	Max nu at ψ ≅ 58°
#1 - Mid Chord	20	3.97	3.55	3.76	0.42	-1197	739	in-lb	1	Max fwd at ψ ≅ 318°
#1 - Mid Flap	22	3.90	2.65	3.28	1.25	- 165	375	in-lb	1&3	Max flap at ψ ≅ 298°
#1 - Mid Torsion	24	3.34	3.24	3.29	0.10	- 15	149	in-lb	1&6	
#1 - Outbd. Flap	26	2.04	0.80	1.42	1.24	- 232	236	in-lb	1&3	Max flap at ψ ≅ 304°
Model Attitude	27			2.97		7.5		deg		
Collective Pitch	29			2.12		6.2		deg		
#1 - Cyclic Pitch	10	3.30	2.70	3.00	0.60	1.1	6.8	deg	1	Max θ at ψ ≅ 16°
#2 - Cyclic Pitch	11	2.96	2.30	2.63	0.66	0	7.7	deg	1	Max θ at ψ ≅ 21°
#3 - Cyclic Pitch	12	2.77	2.12	2.45	0.65	1.5	7.9	deg	1	Max θ at ψ ≅ 352°
Gyro Roll Pos.	19			4.66		- 0.6		deg		
Gyro Pitch Pos.	21			3.82		- 2.7		deg		
Thrust	33			1.50		343		lb		
Drag	31			2.00		66		lb		
Roll Moment	23			4.16		422		in-lb		
Pitch Moment	25			3.02		25		in-lb		
Lat. Vibration	28	2.20	1.91		0.29		0.050	fps	2	
Long. Vibration	30	1.58	1.34		0.24		0.027	fps	3	
Vert. Vibration	32	1.17	0.46		0.71		0.040	fps	3	

TABLE 13.7 CONFIGURATION C

ITEM	#2046 OSCILLOGRAPH RECORD					REDUCED DATA				$n = .91$ $V_H = 50$ MPH
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.	COMMENTS
φ1 - Drag Link	6	3.26	2.86	3.06	0.40	-126	44	lb	1	Max fwd at ψ = 319°
φ2 - Drag Link	7	2.75	2.14	2.45	0.61	-167	68	lb	1	Max fwd at ψ = 344°
φ3 - Drag Link										
φ1 - Inbd. Flap										
φ2 - Inbd. Flap	14	2.20	2.02	2.11	0.18	218	178	in-lb	1	Max flap at ψ = 205°
φ3 - Inbd. Flap	15	1.91	1.64	1.78	0.28	137	274	in-lb	1	Max flap at ψ = 300°
φ1 - Pitch Link	16	1.05	0.81	0.93	0.24	-49	32	lb	1&3	Max nu at ψ = 79°
φ2 - Pitch Link	17									
φ3 - Pitch Link	18	2.11	0.91	1.51	1.20	119	188	lb	1&4	Max nu at ψ = 41°
φ1 - Mid Chord	20	3.90	3.69	3.80	0.21	-1126	370	in-lb	1&2	Max fwd at ψ = 288°
φ1 - Mid Flap	22	5.52	4.76	5.14	0.76	393	228	in-lb	1&3	Max flap at ψ = 300°
φ1 - Mid Torsion	24	3.34	3.29	3.32	0.05	30	75	in-lb	6	
φ1 - Outbd. Flap	26	1.80	1.03	1.42	0.77	-232	147	in-lb	1&3	Max flap at ψ = 312°
Model Attitude	27			2.18		3.1		deg		
Collective Pitch	29			2.01		4.9		deg		
φ1 - Cyclic Pitch	10	3.04	2.70	2.87	0.34	-0.3	3.9	deg	1	Max ∡ at ψ = 22°
φ2 - Cyclic Pitch	11	2.72	2.31	2.52	0.41	-1.3	4.8	deg	1	Max ∡ at ψ = 16°
φ3 - Cyclic Pitch	12	2.50	2.12	2.31	0.38	-0.2	4.6	deg	1	Max ∡ at ψ = 357°
Gyro Roll Pos.	19			4.71		-0.1		deg		
Gyro Pitch Pos.	21			3.93		-1.7		deg		
Thrust	33			1.35		285		lb		
Drag	31			1.10		-6		lb		
Roll Moment	23			3.96		105		in-lb		
Pitch Moment	25			3.00		18		in-lb		
Lat. Vibration	28	2.22	1.91		0.31		0.053	fps	2	
Long. Vibration	30	1.57	1.36		0.21		0.023	fps	2	
Vert. Vibration	32	1.14	0.58		0.56		0.032	fps	2	

TABLE 13.8 CONFIGURATION C

n = .36 V_M = 50 MPH ITEM	#2050 OSCILLOGRAPH RECORD					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link	6	3.24	3.02	3.13	0.22	- 119	23	lb	1
#2 - Drag Link	7	2.80	2.40	2.60	0.40	- 150	45	lb	1
#3 - Drag Link									
#1 - Inbd. Flap									
#2 - Inbd. Flap	14	2.14	1.74	1.94	0.40	50	396	in-lb	1
#3 - Inbd. Flap	15	1.81	1.40	1.61	0.41	- 29	402	in-lb	1
#1 - Pitch Link	16	0.98	0.86	0.92	0.12	- 50	16	lb	1&4
#2 - Pitch Link	17	-0.37	-0.55	-0.46	0.18	- 75	25	lb	1&4
#3 - Pitch Link	18	1.60	1.50	1.55	0.10	126	16	lb	1&4
#1 - Mid Chord	20	3.82	3.64	3.73	0.18	-1250	317	in-lb	1
#1 - Mid Flap	22	3.98	3.58	3.78	0.40	- 15	120	in-lb	1&3
#1 - Mid Torsion	24			3.32		30		in-lb	
#1 - Outbd. Flap	26	2.15	1.80	1.98	0.35	- 125	67	in-lb	1&3
Model Attitude	27			1.14		-17.0		deg	
Collective Pitch	29			2.00		4.8		deg	
#1 - Cyclic Pitch	10	2.87	2.84	2.86	0.03	- 0.5	0.4	deg	1
#2 - Cyclic Pitch	11	2.58	2.44	2.51	0.14	- 1.4	1.6	deg	1
#3 - Cyclic Pitch	12	2.33	2.24	2.29	0.09	- 0.5	1.1	deg	1
Gyro Roll Pos.	19			4.78		0.6		deg	
Gyro Pitch Pos.	21			4.05		-0.6		deg	
Thrust	33			0.91		113		lb	
Drag	31			1.10		- 6		lb	
Roll Moment	23			3.35		- 55		in-lb	
Pitch Moment	25			2.85		- 36		in-lb	
Lat. Vibration	28	2.27	1.86		0.41		0.070	fps	2
Long. Vibration	30	1.60	1.32		0.28		0.032	fps	2
Vert. Vibration	32	1.10	0.66		0.44		0.025	fps	2

TABLE 13.7 CONFIGURATION C

ITEM	#2046 OSCILLOGRAPH RECORD					REDUCED DATA				$n = .91$ $V_H = 50$ MPH
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.	COMMENTS
ϕ1 - Drag Link	6	3.26	2.86	3.06	0.40	-126	44	lb	1	Max fwd at ψ = 319°
ϕ2 - Drag Link	7	2.75	2.14	2.45	0.61	-167	68	lb	1	Max fwd at ψ = 344°
ϕ3 - Drag Link										
ϕ1 - Inbd. Flap										
ϕ2 - Inbd. Flap	14	2.20	2.02	2.11	0.18	218	178	in-lb	1	Max flap at ψ = 205°
ϕ3 - Inbd. Flap	15	1.91	1.64	1.78	0.28	137	274	in-lb	1	Max flap at ψ = 300°
ϕ1 - Pitch Link	16	1.05	0.81	0.93	0.24	-49	32	lb	143	Max nu at ψ = 79°
ϕ2 - Pitch Link	17									
ϕ3 - Pitch Link	18	2.11	0.91	1.51	1.20	119	188	lb	144	Max nu at ψ = 41°
ϕ1 - Mid Chord	20	3.90	3.69	3.80	0.21	-1126	370	in-lb	142	Max fwd at ψ = 288°
ϕ1 - Mid Flap	22	5.52	4.76	5.14	0.76	393	228	in-lb	143	Max flap at ψ = 300°
ϕ1 - Mid Torsion	24	3.34	3.29	3.32	0.05	30	75	in-lb	6	
ϕ1 - Outbd. Flap	26	1.80	1.03	1.42	0.77	-232	147	in-lb	143	Max flap at ψ = 312°
Model Attitude	27			2.18		3.1		deg		
Collective Pitch	29			2.01		4.9		deg		
ϕ1 - Cyclic Pitch	10	3.04	2.70	2.87	0.34	-0.3	3.9	deg	1	Max ∡ at ψ = 22°
ϕ2 - Cyclic Pitch	11	2.72	2.31	2.52	0.41	-1.3	4.8	deg	1	Max ∡ at ψ = 16°
ϕ3 - Cyclic Pitch	12	2.50	2.12	2.31	0.38	-0.2	4.6	deg	1	Max ∡ at ψ = 357°
Gyro Roll Pos.	19			4.71		-0.1		deg		
Gyro Pitch Pos.	21			3.93		-1.7		deg		
Thrust	33			1.35		285		lb		
Drag	31			1.10		-6		lb		
Roll Moment	23			3.96		105		in-lb		
Pitch Moment	25			3.00		18		in-lb		
Lat. Vibration	28	2.22	1.91		0.31		0.053	fps	2	
Long. Vibration	30	1.57	1.36		0.21		0.023	fps	2	
Vert. Vibration	32	1.14	0.58		0.56		0.032	fps	2	

TABLE 13.8 CONFIGURATION C

n = .36 V_M = 50 MPH	#2050 OSCILLOGRAPH RECORD					REDUCED DATA			
ITEM	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link	6	3.24	3.02	3.13	0.22	- 119	23	lb	1
#2 - Drag Link	7	2.80	2.40	2.60	0.40	- 150	45	lb	1
#3 - Drag Link									
#1 - Inbd. Flap									
#2 - Inbd. Flap	14	2.14	1.74	1.94	0.40	50	396	in-lb	1
#3 - Inbd. Flap	15	1.81	1.40	1.61	0.41	- 29	402	in-lb	1
#1 - Pitch Link	16	0.98	0.86	0.92	0.12	- 50	16	lb	1&4
#2 - Pitch Link	17	-0.37	-0.55	-0.46	0.18	- 75	25	lb	1&4
#3 - Pitch Link	18	1.60	1.50	1.55	0.10	126	16	lb	1&4
#1 - Mid Chord	20	3.82	3.64	3.73	0.18	-1250	317	in-lb	1
#1 - Mid Flap	22	3.98	3.58	3.78	0.40	- 15	120	in-lb	1&3
#1 - Mid Torsion	24			3.32		30		in-lb	
#1 - Outbd. Flap	26	2.15	1.80	1.98	0.35	- 125	67	in-lb	1&3
Model Attitude	27			1.14		-17.0		deg	
Collective Pitch	29			2.00		4.8		deg	
#1 - Cyclic Pitch	10	2.87	2.84	2.86	0.03	- 0.5	0.4	deg	1
#2 - Cyclic Pitch	11	2.58	2.44	2.51	0.14	- 1.4	1.6	deg	1
#3 - Cyclic Pitch	12	2.33	2.24	2.29	0.09	- 0.5	1.1	deg	1
Gyro Roll Pos.	19			4.78		0.6		deg	
Gyro Pitch Pos.	21			4.05		-0.6		deg	
Thrust	33			0.91		113		lb	
Drag	31			1.10		- 6		lb	
Roll Moment	23			3.35		- 55		in-lb	
Pitch Moment	25			2.85		- 36		in-lb	
Lat. Vibration	28	2.27	1.86		0.41		0.070	fps	2
Long. Vibration	30	1.60	1.32		0.28		0.032	fps	2
Vert. Vibration	32	1.10	0.66		0.44		0.025	fps	2

TABLE 13.9 CONFIGURATION C

ITEM	#2052 OSCILLOGRAPH RECORD					REDUCED DATA				$n = 1.47$ $V_M = 50$ MPH
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.	COMMENTS
#1 - Drag Link	6	3.50	2.70	3.10	0.80	-122	87	lb	1	Max fwd at ψ = 344°
#2 - Drag Link	7	3.20	2.12	2.66	1.08	-143	121	lb	1	Max fwd at ψ = 11°
#3 - Drag Link										
#1 - Inbd. Flap										
#2 - Inbd. Flap	14	2.35	2.06	2.21	0.29	317	287	in-lb	1	Max flap at ψ = 300°
#3 - Inbd. Flap	15	2.13	1.69	1.91	0.44	265	431	in-lb	1	Max flap at ψ = 308°
#1 - Pitch Link	16	1.09	0.86	0.98	0.23	-42	30	lb	1	Max nu at ψ = 73°
#2 - Pitch Link	17									Max nu at ψ = 74°
#3 - Pitch Link	18	1.70	1.47	1.59	0.23	132	36	lb	1	Max nu at ψ = 48°
#1 - Mid Chord	20	4.00	3.63	3.82	0.37	-1091	651	in-lb	1	Max fwd at ψ = 333°
#1 - Mid Flap	22	2.55	1.95	2.25	0.60	-474	180	in-lb	1&2	Max flap at ψ = 271°
#1 - Mid Torsion	24	3.36	3.30	3.33	0.06	44	89	in-lb	6	
#1 - Outbd. Flap	26	1.84	1.20	1.52	0.64	-213	122	in-lb	1&2	Max flap at ψ = 308°
Model Attitude	27			2.98		7.6		deg		
Collective Pitch	29			2.01		4.9		deg		
#1 - Cyclic Pitch	10	3.13	2.64	2.89	0.49	-0.1	5.6	deg	1	Max [illegible] at ψ = 15°
#2 - Cyclic Pitch	11	2.80	2.24	2.52	0.56	-1.3	6.5	deg	1	Max [illegible] at ψ = 23°
#3 - Cyclic Pitch	12	2.58	2.03	2.31	0.55	-0.2	6.7	deg	1	Max [illegible] at ψ = 351°
Gyro Roll Pos.	19			4.71		-0.1		deg		
Gyro Pitch Pos.	21			3.87		-2.3		deg		
Thrust	33			1.80		460		lb		
Drag	31			2.05		70		lb		
Roll Moment	23			4.75		312		in-lb		
Pitch Moment	25			3.03		29		in-lb		
Lat. Vibration	28	2.21	1.95		0.26		0.045	fps	2	
Long. Vibration	30	1.57	1.35		0.22		0.025	fps	3	
Vert. Vibration	32	1.10	0.62		0.48		0.027	fps	2	

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TABLE 13.10 CONFIGURATION C

ITEM	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.	COMMENTS
	[illegible] OSCILLOGRAPH RECORD					REDUCED DATA				μ = .45, V_H = 106 MPH
φ1 - Drag Link	6	3.31	2.69	3.00	0.62	-133	68	lb	1	Max fwd at ψ ≈ 302°
φ2 - Drag Link	7	2.94	2.12	2.53	0.82	-158	92	lb	1	Max fwd at ψ ≈ 348°
φ3 - Drag Link										
φ1 - Inbd. Flap										
φ2 - Inbd. Flap	14	2.21	1.92	2.07	0.29	178	287	in-lb	1	Max flap at ψ ≈ 186°
φ3 - Inbd. Flap	15	1.86	1.61	1.74	0.25	98	205	in-lb	1	Max flap at ψ ≈ 246°
φ1 - Pitch Link	16	0.96	0.57	0.77	0.39	-73	52	lb	1 & 4	Max nu at ψ ≈ 73°
φ2 - Pitch Link	17									
φ3 - Pitch Link	18	1.33	1.03	1.18	0.30	68	47	lb	1 & 4	Max nu at ψ ≈ 26°
φ1 - Mid Chord	20									
φ1 - Mid Flap	22	3.46	2.66	3.06	0.80	-231	240	in-lb	1 & 3	Max flap at ψ ≈ 294°
φ1 - Mid Torsion	24	3.33	3.26	3.30	0.07	0	104	in-lb		
φ1 - Outbd. Flap	26	2.25	1.43	1.84	0.82	-152	196	in-lb	1 & 3	Max flap at ψ ≈ 306°
Model Attitude	27			1.79		-8.3		deg		
Collective Pitch	29			2.23		7.4		deg		
φ1 - Cyclic Pitch	10	3.41	2.77	3.09	0.64	2.2	7.3	deg	1	Max θ at ψ ≈ 348°
φ2 - Cyclic Pitch	11	3.07	2.38	2.73	0.69	1.2	8.0	deg	1	Max θ at ψ ≈ 348°
φ3 - Cyclic Pitch	12	2.85	2.15	2.50	0.70	2.1	8.5	deg	1	Max θ at ψ ≈ 327°
Gyro Roll Pos.	19			4.84		1.2		deg		
Gyro Pitch Pos.	21			3.82		-2.7		deg		
Thrust	[illegible]			1.39		300		lb		
Drag	[illegible]			1.10		-6		lb		
Roll Moment	[illegible]			3.00		-147		in-lb		
Pitch Moment	[illegible]			3.62		239		in-lb		
Lat. Vibration	28	2.80	1.86		0.94		0.098	fps		
Long. Vibration	30	1.68	1.43		0.25		0.089	fps		
Vert. Vibration	32	1.10	0.53		0.57		0.092	fps		

TABLE 13.11 CONFIGURATION C

ITEM	# 2056 OSCILLOGRAPH RECORD					REDUCED DATA			
n = .44 V_M = 106 MPH	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link	6	3.08	2.85	2.97	0.23	- 136	25	lb	1
#2 - Drag Link	7	2.70	2.45	2.58	0.25	- 152	28	lb	1
#3 - Drag Link									
#1 - Inbd. Flap	14	2.12	1.72	1.92	0.40	30	396	in-lb	1
#2 - Inbd. Flap	15	1.79	1.39	1.59	0.40	- 49	392	in-lb	1
#3 - Inbd. Flap									
#1 - Pitch Link	16	0.89	0.61	0.75	0.28	- 73	37	lb	1 & 4
#2 - Pitch Link	17								
#3 - Pitch Link	18	1.21	0.98	1.10	0.23	55	36	lb	1 & 4
#1 - Mid Chord	20	3.87	3.69	3.78	0.18	-1161	317	in-lb	1
#1 - Mid Flap	22	3.3[illegible]	2.66	3.02	0.72	- 243	216	in-lb	1 & 3
#1 - Mid Torsion	24	3.32	3.26	3.29	0.06	- 15	89	in-lb	
#1 - Outbd. Flap	26	2.45	1.83	2.14	0.62	- 95	118	in-lb	1 & 3
Model Attitude	27			1.37		-13.9		deg	
Collective Pitch	29			2.23		7.4		deg	
#1 - Cyclic Pitch	10	3.25	2.88	3.07	0.37	1.9	4.2	deg	1
#2 - Cyclic Pitch	11	2.92	2.47	2.70	0.45	0.8	5.2	deg	1
#3 - Cyclic Pitch	12	2.66	2.24	2.45	0.42	1.5	5.1	deg	1
Gyro Roll Pos.	19			4.84		1.2		deg	
Gyro Pitch Pos.	21			3.92		- 1.8		deg	
Thrust	33			0.97		137		lb	
Drag	31			1.10		- 6		lb	
Roll Moment	23			3.58		5		in-lb	
Pitch Moment	25			3.03		29		in-lb	
Lat. Vibration	28	2.19	1.9[illegible]		0.28		0.048	fps	
Long. Vibration	30	1.72	1.23		0.49		0.056	fps	
Vert. Vibration	32	1.05	0.63		0.42		0.024	fps	

TABLE 13.12 CONFIGURATION C

ITEM n = 1.42 V_M = 106 MPH	#2058 OSCILLOGRAPH RECORD TR. No.	MAX	MIN	AVE	2A	REDUCED DATA AVE	2A	UNITS	CYC REV.
#1 - Drag Link	6	3.50	2.45	2.98	1.05	- 135	115	lb	1
#2 - Drag Link	7	3.20	1.91	2.56	1.29	- 155	144	lb	1
#3 - Drag Link									
#1 - Inbd. Flap	14	2.31	1.98	2.15	0.33	257	327	in-lb	1
#2 - Inbd. Flap	15	2.04	1.69	1.87	0.35	225	343	in-lb	1
#3 - Inbd. Flap									
#1 - Pitch Link	16	1.00	0.58	0.79	0.42	- 67	55	lb	1 & 4
#2 - Pitch Link	17								
#3 - Pitch Link	18	1.33	0.98	1.16	0.35	64	55	lb	1 & 4
#1 - Mid Chord	20	4.02	3.54	3.78	0.48	-1161	845	in-lb	1
#1 - Mid Flap	22	3.71	2.85	3.28	0.86	- 165	258	in-lb	
#1 - Mid Torsion	24	3.32	3.23	3.28	0.09	- 30	134	in-lb	6
#1 - Outbd. Flap	26	2.07	1.10	1.59	0.97	- 200	184	in-lb	
Model Attitude	27			2.17		- 3.2		deg	
Collective Pitch	29			2.23		7.4		deg	
#1 - Cyclic Pitch	10	3.44	2.68	3.06	0.76	1.8	8.7	deg	1
#2 - Cyclic Pitch	11	3.08	2.30	2.69	0.78	0.7	9.1	deg	1
#3 - Cyclic Pitch	12	2.82	2.02	2.42	0.80	1.1	9.8	deg	1
Gyro Roll Pos.	19			4.83		1.1		deg	
Gyro Pitch Pos.	21			3.75		- 3.3		deg	
Thrust	33			1.76		445		lb	
Drag	31			1.35		14		lb	
Roll Moment	23			3.43		- 34		in-lb	
Pitch Moment	25			3.37		150		in-lb	
Lat. Vibration	28	2.27	1.80		0.47		0.080	fps	
Long. Vibration	30	1.65	1.22		0.43		0.049	fps	
Vert. Vibration	32	1.10	0.54		0.56		0.032	fps	

TABLE 13.13 CONFIGURATION C

ITEM	#2060 OSCILLOGRAPH RECORD					REDUCED DATA				$n = 1.7$[illegible] $V_H = 106$ MPH
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.	COMMENTS
#1 - Drag Link	6	3.60	2.38	2.99	1.22	-134	133	lb	1	Max fwd at ψ = 321°
#2 - Drag Link	7	3.26	1.88	2.57	1.38	-153	155	lb	1	Max fwd at ψ = 334°
#3 - Drag Link										
#1 - Inbd. Flap										
#2 - Inbd. Flap	14	2.45	2.02	[illegible]	0.43	-347	425	in-lb	1	Max flap at ψ = 233°
#3 - Inbd. Flap	15	2.16	1.71	1.94	0.45	294	441	in-lb	1	Max flap at ψ = 257°
#1 - Pitch Link	16	1.10	0.54	0.82	0.56	-63	74	lb	144	Max nu at ψ = [illegible]°
#2 - Pitch Link	17									
#3 - Pitch Link	18	1.50	1.10	1.30	0.40	86	63	lb	144	Max nu at ψ = 28°
#1 - Mid Chord	20	4.00	3.54	3.77	[illegible]	-1179	810	in-lb	1	Max fwd at ψ = 321°
#1 - Mid Flap	22	2.60	1.70	2.15	0.90	-504	270	in-lb	346	Max flap at ψ = 270°
#1 - Mid Torsion	24	3.36	3.21	3.29	0.15	-15	224	in-lb	6	
#1 - Outbd. Flap	26	1.95	0.93	1.44	1.02	-228	194	in-lb	346	Max flap at ψ = 295°
Model Attitude	27			2.42		0.1		deg		
Collective Pitch	29			2.22		+7.3		deg		
#1 - Cyclic Pitch	10	3.51	2.69	3.10	0.82	2.3	9.4	deg	1	Max ∡ at ψ = 343°
#2 - Cyclic Pitch	11	3.13	2.24	2.69	0.89	0.7	10.3	deg	1	Max ∡ at ψ = 343°
#3 - Cyclic Pitch	12	2.82	1.93	2.38	0.89	0.6	10.9	deg	1	Max ∡ at ψ = 319°
Gyro Roll Pos.	19			4.33		1.1		deg		
Gyro Pitch Pos.	21			3.70		-3.3		deg		
Thrust	33			2.06		562		lb		
Drag	31			1.79		49		lb		
Roll Moment	23			3.70		37		in-lb		
Pitch Moment	25			3.50		304		in-lb		
Lat. Vibration	28	2.20	1.83		0.37		0.003	fps		
Long. Vibration	30	1.60	1.30		0.30		0.034	fps		
Vert. Vibration	32	1.11	0.55		0.56		0.032	fps		

TABLE 14.1 CONFIGURATION D

n = .77 V_M = 0 MPH	#2076 OSCILLOGRAPH RECORD					REDUCED DATA			
ITEM	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link	6	3.10	2.99	3.05	0.11	- 128	12	lb	
#2 - Drag Link	7	3.03	2.92	2.98	0.11	- 108	12	lb	
#3 - Drag Link									
#1 - Inbd. Flap									
#2 - Inbd. Flap	14	2.06	1.97	2.02	0.09	129	89	in-lb	1
#3 - Inbd. Flap	15	1.71	1.59	1.65	0.12	10	118	in-lb	1
#1 - Pitch Link	16	0.82	0.76	0.79	0.06	- 67	8	lb	
#2 - Pitch Link	17	0.44	0.39	0.42	0.05	- 80	7	lb	
#3 - Pitch Link	18	0.52	0.43	0.48	0.09	- 42	14	lb	1
#1 - Mid Chord	20	3.71	3.61	3.66	0.10	-1373	176	in-lb	
#1 - Mid Flap	22								
#1 - Mid Torsion	24			3.21		- 134		in-lb	
#1 - Outbd. Flap	26	2.62	2.42	2.52	0.20	- 23	38	in-lb	
Model Attitude	27			2.38		- 0.4		deg	
Collective Pitch	29			2.23		7.4		deg	
#1 - Cyclic Pitch	10			3.18		3.2		deg	
#2 - Cyclic Pitch	11	2.83	2.80	2.82	0.03	2.2	0.3	deg	1
#3 - Cyclic Pitch	12	2.54	2.51	2.53	0.03	2.4	0.4	deg	1
Gyro Roll Pos.	19			4.74		0.2		deg	
Gyro Pitch Pos.	21			4.13		0.1		deg	
Thrust	33			1.24		242		lb	
Drag	31			1.15		- 2		lb	
Roll Moment	23			3.47		- 24		in-lb	
Pitch Moment	25			2.89		- 21		in-lb	
Lat. Vibration	28	2.20	1.92		0.28		0.048	fps	
Long. Vibration	30	1.55	1.37		0.18		0.021	fps	
Vert. Vibration	32	1.01	0.74		0.27		0.015	fps	

TABLE 14.2 CONFIGURATION D

ITEM	# 2079 OSCILLOGRAPH RECORD					REDUCED DATA			
n = 1.27 V_M = 0 MPH	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link	6	2.74	2.60	2.67	0.14	- 169	15	lb	1
#2 - Drag Link	7	2.60	2.40	2.50	0.20	- 161	22	lb	1
#3 - Drag Link									
#1 - Inbd. Flap									
#2 - Inbd. Flap	14	2.23	2.05	2.14	0.18	248	178	in-lb	1
#3 - Inbd. Flap	15	1.89	1.62	1.76	0.27	117	265	in-lb	1
#1 - Pitch Link	16	0.66	0.54	0.60	0.12	- 92	16	lb	3
#2 - Pitch Link	17	0.06	-0.04	0.05	0.02	- 131	3	lb	3
#3 - Pitch Link	18	0.54	0.42	0.48	0.12	- 42	19	lb	3
#1 - Mid Chord	20	3.68	3.52	3.60	0.16	- 1478	282	in-lb	1
#1 - Mid Flap	22								
#1 - Mid Torsion	24	3.21	3.18	3.20	0.03	- 149	45	in-lb	6
#1 - Outbd. Flap	26	2.30	2.03	2.17	0.27	- 89	51	in-lb	3
Model Attitude	27			2.49		1.1		deg	
Collective Pitch	29								
#1 - Cyclic Pitch	10			3.50		6.8		deg	
#2 - Cyclic Pitch	11	3.09	3.04	3.07	0.05	5.1	0.6	deg	1
#3 - Cyclic Pitch	12	2.82	2.77	2.80	0.05	5.7	0.6	deg	1
Gyro Roll Pos.	19			4.76		0.4		deg	
Gyro Pitch Pos.	21	4.18	4.14	4.16	0.04	3.6	0.36	deg	2
Thrust	33			1.67		398		lb	
Drag	31			1.18		0		lb	
Roll Moment	23			3.64		21		in-lb	
Pitch Moment	25			2.62		- 118		in-lb	
Lat. Vibration	28	2.17	1.89		0.28		0.048	fps	1
Long. Vibration	30	1.62	1.29		0.33		0.038	fps	1 & 3
Vert. Vibration	32	1.09	0.65		0.44		0.025	fps	1 & 3

TABLE 14.3 CONFIGURATION D

ITEM	# 2081 OSCILLOGRAPH RECORD					REDUCED DATA			
n = .74 V_M = 25 MPH	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link #2 - Drag Link #3 - Drag Link	6 7	3.15 3.03	2.65 2.41	2.90 2.72	0.50 0.62	- 143 - 137	55 69	lb lb	1 1
#1 - Inbd. Flap #2 - Inbd. Flap #3 - Inbd. Flap	14 15	2.22 1.95	1.86 1.42	2.04 1.69	0.36 0.53	149 49	356 519	in-lb in-lb	1 1
#1 - Pitch Link #2 - Pitch Link #3 - Pitch Link	16 17 18	0.96 0.14 1.11	0.77 -0.18 0.91	0.87 0.16 1.01	0.19 0.04 0.20	- 97 - 116 41	25 6 31	lb lb lb	1 & 3 1 & 3 1 & 3
#1 - Mid Chord #1 - Mid Flap #1 - Mid Torsion #1 - Outbd. Flap	20 22 24 26	3.67 3.23 2.45	3.35 3.18 1.99	3.51 3.21 2.02	0.32 0.05 0.86	-1637 - 134 - 118	563 75 163	in-lb in-lb in-lb	 6 1 & 3
Model Attitude Collective Pitch #1 - Cyclic Pitch #2 - Cyclic Pitch #3 - Cyclic Pitch	27 29 10 11 12	 3.24 2.88 2.96	 2.86 2.46 2.20	2.30 2.09 3.05 2.67 2.38	 0.38 0.42 0.36	- 1.5 5.8 1.7 0.5 0.6	 4.3 4.9 4.4	deg deg deg deg deg	 1 1 1
Gyro Roll Pos. Gyro Pitch Pos.	19 21			4.60 3.93		- 1.2 - 1.7		deg deg	
Thrust Drag Roll Moment Pitch Moment	33 31 23 25			1.22 1.08 5.42 2.73		234 - 8 489 - 79		lb lb in-lb in-lb	
Lat. Vibration Long. Vibration Vert. Vibration	28 30 32	2.15 1.59 1.16	1.93 1.36 0.55		0.22 0.23 0.61		0.058 0.088 0.095	fps fps fps	

TABLE 14.4 CONFIGURATION D

ITEM μ = .5 V_M = 25 MPH	# 2083 OSCILLOGRAPH RECORD					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link	6	2.98	2.74	2.86	0.24	- 148	26	lb	1
#2 - Drag Link	7	2.94	2.44	2.69	0.50	- 140	56	lb	1
#3 - Drag Link									
#1 - Inbd. Flap									
#2 - Inbd. Flap	14	2.19	1.72	1.96	0.47	69	465	in-lb	1
#3 - Inbd. Flap	15	1.88	1.33	1.61	0.55	- 29	539	in-lb	1
#1 - Pitch Link	16	0.92	0.82	0.87	0.10	- 58	13	lb	3
#2 - Pitch Link	17	-0.07	-0.28	0.18	0.21	- 113	29	lb	1
#3 - Pitch Link	18	1.16	1.06	1.11	0.10	57	16	lb	1
#1 - Mid Chord	20	3.62	3.15	3.39	0.47	-1848	827	in-lb	1
#1 - Mid Flap	22								
#1 - Mid Torsion	24			3.20		- 149		in-lb	
#1 - Outbd. Flap	26	2.28	1.86	2.07	0.42	- 108	80	in-lb	1 & 3
Model Attitude	27			1.12		-17.3		deg	
Collective Pitch	29			2.09		5.8		deg	
#1 - Cyclic Pitch	10	3.04	3.02	3.03	0.02	1.5	0.2	deg	1
#2 - Cyclic Pitch	11	2.74	2.58	2.66	0.16	0.3	1.9	deg	1
#3 - Cyclic Pitch	12	2.41	2.32	2.37	0.09	0.5	1.1	deg	1
Gyro Roll Pos.	19			4.64		- 0.8		deg	
Gyro Pitch Pos.	21			4.04		- 0.7		deg	
Thrust	33			1.02		156		lb	
Drag	31			1.07		- 9		lb	
Roll Moment	23			4.17		160		in-lb	
Pitch Moment	25			2.89		- 21		in-lb	
Lat. Vibration	28	2.15	1.96		0.19		0.032	fps	
Long. Vibration	30	1.59	1.30		0.29		0.033	fps	
Vert. Vibration	32	1.03	0.69		0.34		0.019	fps	

TABLE 14.5 CONFIGURATION D

ITEM	# 2085 OSCILLOGRAPH RECORD					REDUCED DATA			
n = .94 V_M = 25 MPH	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link	6	3.24	2.47	2.86	0.77	- 148	84	lb	1
#2 - Drag Link	7	3.19	2.17	2.68	1.02	- 141	114	lb	1
#3 - Drag Link									
#1 - Inbd. Flap									
#2 - Inbd. Flap	14	2.31	1.82	2.07	0.49	178	485	in-lb	1
#3 - Inbd. Flap	15	2.05	1.38	1.72	0.67	78	657	in-lb	1
#1 - Pitch Link	16	1.01	0.74	0.88	0.27	- 55	36	lb	1
#2 - Pitch Link	17								
#3 - Pitch Link	18	1.38	1.13	1.26	0.25	80	39	lb	1
#1 - Mid Chord	20	3.69	3.39	3.54	0.30	-1584	528	in-lb	1
#1 - Mid Flap	22								
#1 - Mid Torsion	24	3.24	3.17	3.21	0.07	- 134	104	in-lb	6
#1 - Outbd. Flap	26	2.50	1.42	1.46	0.08	- 224	15	in-lb	1 & 3
Model Attitude	27			2.96		7.4		deg	
Collective Pitch	29			2.08		5.7		deg	
#1 - Cyclic Pitch	10	3.32	2.76	3.04	0.56	1.6	6.4	deg	1
#2 - Cyclic Pitch	11	2.94	2.35	2.65	0.59	0.2	6.9	deg	1
#3 - Cyclic Pitch	12	2.65	2.12	2.39	0.53	0.7	6.5	deg	1
Gyro Roll Pos.	19			4.57		- 1.5		deg	
Gyro Pitch Pos.	21			3.84		- 2.5		deg	
Thrust	33			1.38		296		lb	
Drag	31			1.92		59		lb	
Roll Moment	23			5.88		610		in-lb	
Pitch Moment	25			2.83		- 43		in-lb	
Lat. Vibration	28	2.16	1.95		0.21		0.036	fps	3
Long. Vibration	30	1.62	1.31		0.31		0.035	fps	
Vert. Vibration	32	1.08	0.60		0.48		0.027	fps	3

TABLE 14.6 CONFIGURATION D

ITEM	# 2087 OSCILLOGRAPH RECORD					REDUCED DATA			
n = .78 V_M = 50 MPH	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link	6	3.03	2.69	2.86	0.34	- 148	37	lb	1
#2 - Drag Link	7	2.93	2.47	2.70	0.46	- 139	52	lb	1
#3 - Drag Link									
#1 - Inbd. Flap	14	2.23	1.88	2.06	0.35	168	347	in-lb	1
#2 - Inbd. Flap	15	1.92	1.54	1.73	0.38	88	372	in-lb	1
#3 - Inbd. Flap									
#1 - Pitch Link	16	1.06	0.86	0.96	0.20	- 45	26	lb	1
#2 - Pitch Link	17	0.21	-0.53	0.37	0.32	- 87	44	lb	1
#3 - Pitch Link	18	1.52	1.35	1.44	0.17	108	27	lb	1
#1 - Mid Chord	20	3.67	3.49	3.50	0.18	-1514	317	in-lb	1
#1 - Mid Flap	22								
#1 - Mid Torsion	24			3.20		- 149		in-lb	
#1 - Outbd. Flap	26	2.23	1.44	1.84	0.79	- 152	150	in-lb	3
Model Attitude	27			2.18		- 3.1		deg	
Collective Pitch	29			2.00		4.8		deg	
#1 - Cyclic Pitch	10	3.13	2.82	2.98	0.31	0.9	3.5	deg	1
#2 - Cyclic Pitch	11	2.78	2.37	2.58	0.41	- 0.6	4.8	deg	1
#3 - Cyclic Pitch	12	2.48	2.12	2.30	0.36	- 0.4	4.4	deg	1
Gyro Roll Pos.	19			4.60		- 1.2		deg	
Gyro Pitch Pos.	21			3.93		- 1.7			
Thrust	33			1.25		246		lb	
Drag	31			1.08		- 8		lb	
Roll Moment	23			4.65		287		in-lb	
Pitch Moment	25	2.95	2.70	2.83	0.25	- 43		in-lb	
Lat. Vibration	28	2.14	1.94		0.20		0.034	fps	
Long. Vibration	30	1.64	1.30		0.34		0.039	fps	
Vert. Vibration	32	1.08	0.62		0.46		0.026	fps	

TABLE 14.7 CONFIGURATION D

ITEM	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
	# 2089 OSCILLOGRAPH RECORD					REDUCED DATA			
n = .24, V_H = 50 MPH									
#1 - Drag Link	6	2.96	2.76	2.86	0.20	- 148	22	lb	1
#2 - Drag Link	7	2.86	2.46	2.66	0.40	- 143	45	lb	1
#3 - Drag Link									
#1 - Inbd. Flap									
#2 - Inbd. Flap	14	2.12	1.65	1.89	0.47	0	465	in-lb	1
#3 - Inbd. Flap	15	1.76	1.36	1.56	0.40	- 78	392	in-lb	1
#1 - Pitch Link	16	0.98	0.89	0.94	0.09	- 47	12	lb	1 & 3
#2 - Pitch Link	17	-0.33	-0.44	0.39	0.11	- 84	17	lb	1
#3 - Pitch Link	18	1.42	1.36	1.39	0.06	100	9	lb	1 & 3
#1 - Mid Chord	20	3.62	3.26	3.44	0.36	-1760	634	in-lb	1
#1 - Mid Flap	22								
#1 - Mid Torsion	24			3.21		- 134		in-lb	
#1 - Outbd. Flap	26	2.96	1.92	2.09	0.34	- 105	65	in-lb	3
Model Attitude	27			1.13		-17.2		deg	
Collective Pitch	29			2.00		4.8		deg	
#1 - Cyclic Pitch	10			2.95		0.6		deg	
#2 - Cyclic Pitch	11	2.63	2.52	2.58	0.11	- 0.6	1.3	deg	1
#3 - Cyclic Pitch	12	2.31	2.24	2.28	0.07	- 0.6	0.7	deg	1
Gyro Roll Pos.	19			4.65		- 0.7		deg	
Gyro Pitch Pos.	21			4.05		- 0.6		deg	
Thrust	33			0.81		74		lb	
Drag	31			1.08		- 8		lb	
Roll Moment	23			3.45		- 29		in-lb	
Pitch Moment	25			2.75		- 71		in-lb	
Lat. Vibration	28	2.24	1.93		0.31		0.053	fps	
Long. Vibration	30	1.60	1.30		0.30		0.034	fps	
Vert. Vibration	32	1.10	0.61		0.49		0.028	fps	

TABLE 14.8 CONFIGURATION D

ITEM	# 2091 OSCILLOGRAPH RECORD					REDUCED DATA			
n = 1.34 V_M = 50 MPH	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link	6	3.21	2.52	2.87	0.69	- 147	75	lb	1
#2 - Drag Link	7	3.23	2.28	2.76	0.95	- 132	106	lb	1
#3 - Drag Link									
#1 - Inbd. Flap									
#2 - Inbd. Flap	14	2.37	1.96	2.16	0.41	267	406	in-lb	1
#3 - Inbd. Flap	15	2.12	1.59	1.86	0.53	216	519	in-lb	1
#1 - Pitch Link	16	1.07	0.84	0.96	0.23	- 45	30	lb	1 & 3
#2 - Pitch Link	17	-0.28	-0.58	0.43	0.30	- 79	41	lb	
#3 - Pitch Link	18	1.60	0.86	1.23	0.74	75	116	lb	1 & 3
#1 - Mid Chord	20	3.73	3.41	3.57	0.32	-1531	563	in-lb	1
#1 - Mid Flap	22								
#1 - Mid Torsion	24			3.20		- 149		in-lb	
#1 - Outbd. Flap	26	1.89	1.20	1.55	0.69	- 207	131	in-lb	1 & 2
Model Attitude	27			2.93		7.0		deg	
Collective Pitch	29			1.99		4.7		deg	
#1 - Cyclic Pitch	10	3.18	2.76	2.97	0.42	0.8	4.8	deg	1
#2 - Cyclic Pitch	11	2.86	2.32	2.59	0.54	- 0.5	6.3	deg	1
#3 - Cyclic Pitch	12	2.56	2.07	2.32	0.49	- 0.1	6.0	deg	1
Gyro Roll Pos.	19			4.56		- 1.6		deg	
Gyro Pitch Pos.	21			3.85		- 2.4		deg	
Thrust	33			1.70		421		lb	
Drag	31			2.02		67		lb	
Roll Moment	23			5.25		444		in-lb	
Pitch Moment	25	3.01	2.83	2.92	0.18	- 11	64	in-lb	.070
Lat. Vibration	28	2.18	1.91		0.27		0.046	fps	2
Long. Vibration	30	1.58	1.31		0.27		0.031	fps	2
Vert. Vibration	32	1.02	0.64		0.38		0.022	fps	2

TABLE 14.9 CONFIGURATION D

ITEM	♯ 2093 OSCILLOGRAPH RECORD					REDUCED DATA			
n = .81 V_M = 106 MPH	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
♯1 - Drag Link ♯2 - Drag Link ♯3 - Drag Link	6 7	3.05 2.92	2.44 2.20	2.76 2.56	0.61 0.72	- 159 - 155	66 81	lb lb	1 1
♯1 - Inbd. Flap ♯2 - Inbd. Flap ♯3 - Inbd. Flap	14 15	2.17 1.81	1.90 1.59	2.03 2.70	0.27 0.22	139 59	267 216	in-lb in-lb	1 1
♯1 - Pitch Link ♯2 - Pitch Link ♯3 - Pitch Link	16 17 18	0.92 -0.32 1.27	0.65 -0.67 1.05	0.79 0.50 1.16	0.27 0.35 0.22	- 67 - 69 64	36 48 35	lb lb lb	1 & 3 1 & 3 1 & 3
♯1 - Mid Chord ♯1 - Mid Flap ♯1 - Mid Torsion ♯1 - Outbd. Flap	20 22 24 26	3.22 2.30	3.16 1.50	3.19 1.90	0.06 0.80	- 164 - 141	89 152	in-lb in-lb	1 & 6 3
Model Attitude Collective Pitch ♯1 - Cyclic Pitch ♯2 - Cyclic Pitch ♯3 - Cyclic Pitch	27 29 10 11 12	3.48 3.11 2.86	2.90 2.46 2.20	1.80 2.23 3.19 2.84 2.53	0.58 0.65 0.66	- 8.2 7.4 3.3 2.4 2.4	6.6 7.5 8.1	deg deg deg deg deg	1 1 1
Gyro Roll Pos. Gyro Pitch Pos.	19 21			4.67 3.80		- 0.5 - 2.9		deg deg	
Thrust Drag Roll Moment Pitch Moment	33 31 23 25	3.33	2.93	1.27 1.08 3.48 3.13	0.40	255 - 8 - 21 + 64	143	lb lb in-lb in-lb	
Lat. Vibration Long. Vibration Vert. Vibration	28 30 32	2.20 1.57 1.11	1.92 1.35 0.58		0.28 0.22 0.53		0.048 0.025 0.030	fps fps fps	

TABLE 14.10 CONFIGURATION D

ITEM	# 2095 OSCILLOGRAPH RECORD					REDUCED DATA			
n = .35 V_M = 106 MPH	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link	6	2.83	2.71	2.77	0.12	- 158	13	lb	1
#2 - Drag Link	7	2.72	2.53	2.63	0.19	- 147	21	lb	1
#3 - Drag Link									
#1 - Inbd. Flap									
#2 - Inbd. Flap	14	2.19	1.64	1.92	0.55	30	545	in-lb	1
#3 - Inbd. Flap	15	1.80	1.34	1.57	0.46	- 69	451	in-lb	1
#1 - Pitch Link	16	0.87	0.66	0.77	0.21	- 70	28	lb	1 & 3
#2 - Pitch Link	17	-0.50	-0.78	0.64	0.28	- 50	39	lb	1 & 3
#3 - Pitch Link	18	1.22	1.05	1.14	0.17	61	27	lb	1 & 3
#1 - Mid Chord	20								
#1 - Mid Flap	22								
#1 - Mid Torsion	24			3.20		- 149		in-lb	
#1 - Outbd. Flap	26	2.45	1.83	2.14	0.62	- 95	118	in-lb	3
Model Attitude	27			1.40		-13.5		deg	
Collective Pitch	29			2.22		7.3		deg	
#1 - Cyclic Pitch	10	3.36	2.98	3.17	0.38	3.1	4.3	deg	1
#2 - Cyclic Pitch	11								
#3 - Cyclic Pitch	12	2.74	2.30	2.52	0.44	2.3	5.4	deg	1
Gyro Roll Pos.	19			4.68		- 0.4		deg	
Gyro Pitch Pos.	21			3.89		- 2.1		deg	
Thrust	33			0.90		109		lb	
Drag	31			1.07		- 9		lb	
Roll Moment	23			3.44		- 32		in-lb	
Pitch Moment	25			3.20		89		in-lb	
Lat. Vibration	28	2.20	2.00		0.20		0.034	fps	3
Long. Vibration	30	1.55	1.36		0.19		0.022	fps	1
Vert. Vibration	32	1.11	0.60		0.51		0.029	fps	1

TABLE 14.11 CONFIGURATION D

ITEM	#2097 OSCILLOGRAPH RECORD					REDUCED DATA				$n = 1.24$ $V_M = 106$ MPH
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.	COMMENTS
Ø1 - Drag Link	6	3.15	2.21	2.68	0.94	- 168	102	lb	1	
Ø2 - Drag Link	7	3.12	2.03	2.58	1.09	- 152	122	lb	1	
Ø3 - Drag Link										
Ø1 - Inbd. Flap										
Ø2 - Inbd. Flap	14	2.24	2.04	2.14	0.20	248	198	in-lb	1	
Ø3 - Inbd. Flap	15	1.93	1.70	1.82	0.23	176	225	in-lb	1	
Ø1 - Pitch Link	16	0.95	0.62	0.89	0.33	- 54	44	lb	1	
Ø2 - Pitch Link	17	-0.51	-0.90	0.71	0.39	- 40	54	lb	1	
Ø3 - Pitch Link	18	1.28	1.03	1.16	0.25	64	39	lb	1	
Ø1 - Mid Chord	20	3.84	3.44	3.64	0.40	-1408	704	in-lb	1	
Ø1 - Mid Flap	22									
Ø1 - Mid Torsion	24	3.21	3.14	3.18	0.07	- 179	104	in-lb	1 & 6	
Ø1 - Outbd. Flap	26	2.10	1.21	1.66	0.89	- 186	169	in-lb		
Model Attitude	27			2.15		- 3.5		deg		
Collective Pitch	29			2.23		7.4		deg		
Ø1 - Cyclic Pitch	10	3.55	2.82	3.19	0.73	3.3	8.3	deg	1	
Ø2 - Cyclic Pitch	11	No Signal								
Ø3 - Cyclic Pitch	12	2.92	2.13	2.53	0.79	2.4	9.6	deg	1	
Gyro Roll Pos.	19			4.66		- 0.6		deg		Also Exhibits 0.005" -3/Rev.
Gyro Pitch Pos.	21			3.74		- 3.4		deg		
Thrust	33			1.62		390		lb		
Drag	31			1.27		7		lb		
Roll Moment	23			3.57		3		in-lb		
Pitch Moment	25	2.99	2.58	2.79	0.41	- 57	146	in-lb	.143	
Lat. Vibration	28	2.18	1.90		0.28		0.048	fps	3	
Long. Vibration	30	1.56	1.34		0.22		0.085	fps	2	
Vert. Vibration	32	1.07	0.53		0.54		0.031	fps	2	

TABLE 14.12 CONFIGURATION D

ITEM	∅ 2099 OSCILLOGRAPH RECORD					REDUCED DATA				$n = 1.62$ $V_M = 106$ MPH
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.	COMMENTS
∅1 - Drag Link	6	3.29	2.17	2.73	1.12	- 162	122	lb	1	
∅2 - Drag Link	7	3.21	1.89	2.55	1.32	- 157	148	lb	1	
∅3 - Drag Link										
∅1 - Inbd. Flap										
∅2 - Inbd. Flap	14	2.40	2.07	2.24	0.33	347	327	in-lb	1	
∅3 - Inbd. Flap	15	2.07	1.70	1.89	0.37	245	363	in-lb	1	
∅1 - Pitch Link	16	0.97	0.60	0.79	0.37	- 67	49	lb	1	
∅2 - Pitch Link	17	-0.59	-1.06	0.83	0.47	- 83	65	lb	1	
∅3 - Pitch Link	18	1.37	1.07	1.22	0.30	74	47	lb	1	
∅1 - Mid Chord	20	3.86	3.42	3.64	0.44	-1408	774	in-lb	1	
∅1 - Mid Flap	22								1	
∅1 - Mid Torsion	24	3.23	3.14	3.19	0.09	- 164	134	in-lb	1 & 6	
∅1 - Outbd. Flap	26	1.92	0.91	1.42	1.01	- 232	192	in-lb		
Model Attitude	27			2.43		0.3		deg		
Collective Pitch	29			2.22		7.3		deg		
∅1 - Cyclic Pitch	10	3.65	2.78	3.21	0.87	3.5	9.9	deg	1	
∅2 - Cyclic Pitch	11	No Signal								
∅3 - Cyclic Pitch	12	2.98	2.08	2.53	0.90	2.4	10.9	deg	1	
Gyro Roll Pos.	19			4.68		- 0.4		deg		Also Exhibits 0.006" -3/Rev.
Gyro Pitch Pos.	21			3.68		- 4.0		deg		
Thrust	33			1.92		507		lb		
Drag	31			1.62		35		lb		
Roll Moment	23			3.97		108		in-lb		
Pitch Moment	25			2.40		- 196		in-lb		
Lat. Vibration	28	2.22	1.92		0.30		0.051	fps	3	
Long. Vibration	30	1.58	1.31		0.27		0.031	fps	No Distinct Harmonics	
Vert. Vibration	32	1.06	0.58		0.48		0.027	fps	2	

TABLE 15.1 CONFIGURATION E

ITEM	# 2156 OSCILLOGRAPH RECORD					REDUCED DATA			
n = .81 V_M = 0 MPH	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link	6	2.64	2.50	2.57	0.14	- 101	8	lb	
#2 - Drag Link	7	2.02	1.92	1.97	0.10	- 122	7	lb	
#3 - Drag Link	8	No Record							
#1 - Inbd. Flap	13	No Record							
#2 - Inbd. Flap	14	2.12	2.05	2.09	0.07	- 120	70	in-lb	
#3 - Inbd. Flap	15	1.65	1.58	1.62	0.07	- 293	71	in-lb	
#1 - Pitch Link	16	1.02	0.92	0.97	0.10	- 55	16	lb	
#2 - Pitch Link	17	-.44	-.54	0.49	0.10	- 70	15	lb	
#3 - Pitch Link	18	-.24	-.36	0.30	0.12	- 60	18	lb	
#1 - Mid Chord	20	5.83	5.44	5.64	0.39	140	46	in-lbs	
#1 - Mid Flap	22	4.13	4.04	4.09	0.09				
#1 - Mid Torsion	24	3.24	3.17	3.21	0.07				
#1 - Outbd. Flap	26	3.90	3.72	3.81	0.48				
Model Attitude	27			2.37		- 0.5		deg	
Collective Pitch	29			2.14		6.4		deg	
#1 - Cyclic Pitch	10			3.49		6.7		deg	
#2 - Cyclic Pitch	11			2.94		3.6		deg	
#3 - Cyclic Pitch	12			3.26		11.4		deg	
Gyro Roll Pos.	19	4.72	4.66	4.69	0.06	- 0.3	0.6	deg	
Gyro Pitch Pos.	21	4.16	4.13	4.15	0.03	0.3	0.3	deg	
Thrust	33			1.27		254		lb	
Drag	31			1.19		1		lb	
Roll Moment	23			3.30		- 69		in-lb	
Pitch Moment	25			3.10		54		in-lb	
Lat. Vibration	28	2.26	1.83		0.43		0.074	fps	
Long. Vibration	30	1.61	1.32		0.29		0.033	fps	
Vert. Vibration	32	0.98	0.76		0.22		0.013	fps	

TABLE 15.2 CONFIGURATION I

ITEM n = 1.28 V_M = 0 MPH	TR. No.	ϕ 21.8 OSCILLOGRAPH RECORD MAX	MIN	AVE	2A	REDUCED DATA AVE	2A	UNITS	CYC REV.
ϕ1 - Drag Link	6	2.35	2.14	2.25	0.21	- 120	12	lb	
ϕ2 - Drag Link	7	1.68	1.47	1.58	0.21	- 148	14	lb	
ϕ3 - Drag Link	8								
ϕ1 - Inbd. Flap	13								
ϕ2 - Inbd. Flap	14	2.23	2.10	2.17	0.13	- 40	130	in-lb	
ϕ3 - Inbd. Flap	15	1.78	1.63	1.71	0.15	- 262	152	in-lb	
ϕ1 - Pitch Link	16	0.95	0.75	0.85	0.20	- 73	32	lb	
ϕ2 - Pitch Link	17	-.90	-1.03	0.97	0.13	0	19	lb	
ϕ3 - Pitch Link	18	-.80	-.94	0.87	0.14	11	21	lb	
ϕ1 - Mid Chord	20	5.83	5.00	5.42	0.83	114	98	in-lb	
ϕ1 - Mid Flap	22	4.32	4.04	4.18	0.28				
ϕ1 - Mid Torsion	24	3.22	3.13	3.18	0.09				
ϕ1 - Outbd. Flap	26	4.17	3.80	4.03	0.27				
Model Attitude	27			2.37		- 0.5		deg	
Collective Pitch	29			2.39		9.2		deg	
ϕ1 - Cyclic Pitch	10			3.77		9.9		deg	
ϕ2 - Cyclic Pitch	11			3.17		6.3		deg	
ϕ3 - Cyclic Pitch	12			3.51		14.4		deg	
Gyro Roll Pos.	19	4.72	4.65	4.69	0.07	- 0.3	0.7	deg	
Gyro Pitch Pos.	21	4.16	4.12	4.14	0.04	0.2	0.4	deg	
Thrust	33			1.65		402		lb	
Drag	31			1.20		2		lb	
Roll Moment	23			3.13		- 113		in-lb	
Pitch Moment	25			2.99		14		in-lb	
Lat. Vibration	28	2.35	1.77		0.58		0.099	fps	
Long. Vibration	30	1.65	1.29		0.36		0.041	fps	
Vert. Vibration	32	1.03	0.71		0.32		0.018	fps	

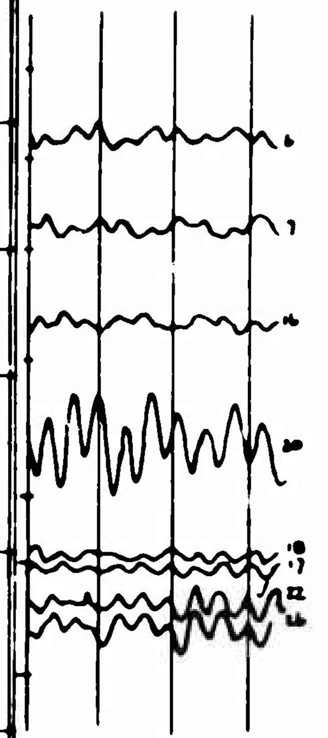


TABLE 15.3 CONFIGURATION E

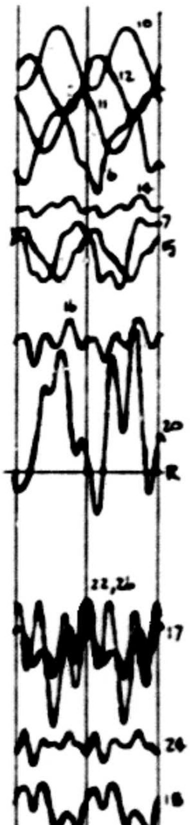
n = .77 V_M = 25 MPH ITEM	#2162 OSCILLOGRAPH RECORD					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link	6	2.83	2.41	2.62	0.42	- 99	25	LB	
#2 - Drag Link	7	2.01	1.59	1.80	0.42	-133	28	lb	
#3 - Drag Link	8								
#1 - Imbd. Flap	13								
#2 - Imbd. Flap	14	2.17	2.04	2.11	0.13	-100	130	in - lb	
#3 - Imbd. Flap	15	1.43	1.59	1.51	0.16	-404	162	in - lb	
#1 - Pitch Link	16	1.19	0.94	1.06	0.25	- 41	39	lb	
#2 - Pitch Link	17	-1.12	-1.34	1.23	0.22	38	32	lb	
#3 - Pitch Link	18	-1.82	-2.06	1.94	0.24	187	36	lb	
#1 - Mid Chord	20	6.37	5.23	5.30	1.14	159	135	in - lb	
#1 - Mid Flap	22	4.26	3.84	4.09	0.42				
#1 - Mid Torsion	24	3.31	3.14	3.28	0.27				
#1 - Outbd. Flap	26	4.26	3.52	3.89	0.74				
Model Attitude	27			2.32		-1.2			
Collective Pitch	29			2.02		5.0			
#1 - Cyclic Pitch	10	3.52	3.20	3.36	0.32	5.3	3.6	deg	
#2 - Cyclic Pitch	11	3.00	2.66	2.83	0.34	2.3	3.9	deg	
#3 - Cyclic Pitch	12	3.26	2.97	3.11	0.29	9.5	3.5	deg	
Gyro Roll Pos.	19	4.62	4.53	4.58	0.09	-1.4	0.9	deg	
Gyro Pitch Pos.	21	3.98	3.91	3.95	0.07	-1.6	0.6	deg	
Thrust	33			1.24		242		lb	
Drag	31			1.08		- 0.8		lb	
Roll Moment	23			3.65		24		in - lb	
Pitch Moment	25			2.95		0			
Lat. Vibration	28	2.26	1.88		0.38		0.065	deg	
Long. Vibration	30	1.70	1.32		0.38		0.043	deg	
Vert. Vibration	32	1.18	0.60		0.58		0.03[illegible]	deg	

TABLE 15.4 CONFIGURATION E

ITEM	TR. No.	OSCILLOGRAPH RECORD ϕ 2164 MAX	MIN	AVE	2A	REDUCED DATA AVE	2A	UNITS	CYC REV.
n = .57 V_M = 25 MPH									
ϕ1 - Drag Link	6	2.78	2.51	2.65	0.27	- 97	16	lb	
ϕ2 - Drag Link	7	1.90	1.67	1.80	0.23	- 133	19	lb	
ϕ3 - Drag Link	8								
ϕ1 - Inbd. Flap	13								
ϕ2 - Inbd. Flap	14	2.20	1.90	2.05	0.30	- 160	300	lb	
ϕ3 - Inbd. Flap	15	1.76	1.56	1.66	0.20	- 253	202	in-lb	
ϕ1 - Pitch Link	16	1.12	1.00	1.06	0.12	- 41	19	lb	
ϕ2 - Pitch Link	17	-1.34	-1.44	1.39	0.10	61	15	lb	
ϕ3 - Pitch Link	18	-2.51	-2.64	2.56	0.13	281	20	lb	
ϕ1 - Mid Chord	20	6.24	5.36	5.80	0.88	159	104	In-lb	
ϕ1 - Mid Flap	22	4.17	3.90	4.03	0.27				
ϕ1 - Mid Torsion	24	3.27	3.17	3.22	0.10				
ϕ1 - Outbd. Flap	26	4.37	3.94	4.15	0.43				
Model Attitude	27			1.15		-16.9		deg	
Collective Pitch	29			2.02		5.0		deg	
ϕ1 - Cyclic Pitch	10	3.40	3.28	3.34	0.12	5.0	1.4	deg	
ϕ2 - Cyclic Pitch	11	2.90	2.76	2.83	0.14	2.3	1.6	deg	
ϕ3 - Cyclic Pitch	12	3.17	3.06	3.12	0.11	9.7	1.3	deg	
Gyro Roll Pos.	19	4.67	4.58	4.63	0.09	- 0.9	0.9	deg	
Gyro Pitch Pos.	21	4.09	3.98	4.01	0.07	- 1.0	0.6	deg	
Thrust	33			1.08		180		lb	
Drag	31			1.07		- 9		lb	
Roll Moment	23			3.47		- 24		in-lb	
Pitch Moment	25			2.74		- 75		in-lb	
Lat. Vibration	28	2.21	1.91		0.30		0.051	fps	
Long. Vibration	30	1.60	1.30		0.30		0.034	fps	
Vert. Vibration	32	1.12	0.59		0.53		0.030	fps	

TABLE 15.5 CONFIGURATION E

n = .95 V_M = 25 MPH ITEM	OSCILLOGRAPH RECORD TR. No.	MAX	MIN	AVE	2A	REDUCED DATA AVE	2A	UNITS	CYC REV.
#1 - Drag Link	6	2.90	2.31	2.61	0.59	- 99	35	lb	
#2 - Drag Link	7	2.05	1.47	1.76	0.58	-136	39	lb	
#3 - Drag Link	8								
#1 - Inbd. Flap	13								
#2 - Inbd. Flap	14	2.23	2.05	2.14	0.18	- 70	180	in-lb	
#3 - Inbd. Flap	15	1.95	1.54	1.75	0.41	-162	414	in-lb	
#1 - Pitch Link	16	1.27	0.85	1.08	0.42	- 41	66	lb	
#2 - Pitch Link	17	-1.25	-1.61	1.43	0.36	67	53	lb	
#3 - Pitch Link	18	-2.51	-2.96	2.74	0.45	308	63	lb	
#1 - Mid Chord	20	6.69	5.11	5.90	1.58	171	186	in-lb	
#1 - Mid Flap	22	4.40	3.71	4.05	0.69				
#1 - Mid Torsion	24	3.34	3.02	3.18	0.32				
#1 - Outbd. Flap	26	4.40	3.34	3.87	1.06				
Model Attitude	27			2.96		7.4		deg	
Collective Pitch	29			2.03		5.1		deg	
#1 - Cyclic Pitch	10	3.60	3.10	3.35	0.50	5.1	5.7	deg	
#2 - Cyclic Pitch	11	3.07	2.58	2.82	0.49	2.2	5.7	deg	
#3 - Cyclic Pitch	12	3.37	2.90	3.14	0.47	9.9	5.8	deg	
Gyro Roll Pos.	19	4.58	4.48	4.53	0.10	-1.9	1.0	deg	
Gyro Pitch Pos.	21	3.92	3.86	3.89	0.06	-2.1	0.5	deg	
Thrust	33			1.39		300		lb	
Drag	31			1.92		59		lb	
Roll Moment	23			4.03		124		in-lb	
Pitch Moment	25			2.89		- 21		in-lb	
Lat. Vibration	28	2.36	1.77		0.59		0.101	fps	
Long. Vibration	30	1.70	1.25		0.45		0.051	fps	
Vert. Vibration	32	1.16	0.53		0.63		0.036	fps	



The 3/REV components of #16, #17, & #18 are all in phase with respect to each other.

TABLE 15.6 CONFIGURATION E

ITEM	# 2168 OSCILLOGRAPH RECORD					REDUCED DATA			
n = .81, V_M = 50 MPH	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link	6	2.82	2.48	2.65	0.34	- 77	20	lb	
#2 - Drag Link	7	1.98	1.75	1.87	0.23	- 129	15	lb	
#3 - Drag Link	8								
#1 - Inbd. Flap	13								
#2 - Inbd. Flap	14	2.28	1.98	2.13	0.30	- 80	300	in-lb	
#3 - Inbd. Flap	15	1.84	1.67	1.76	0.17	- 152	172	in-lb	
#1 - Pitch Link	16	1.26	1.01	1.14	0.25	- 28	39	lb	
#2 - Pitch Link	17	-1.20	-1.40	1.30	0.20	48	29	lb	
#3 - Pitch Link	18	-2.05	-2.22	2.14	0.17	217	26	lb	
#1 - Mid Chord	20	6.42	5.35	5.89	1.07	170	126	in-lb	
#1 - Mid Flap	22	4.30	3.81	4.05	0.49				
#1 - Mid Torsion	24	3.34	3.13	3.24	0.21				
#1 - Outbd. Flap	26	4.09	3.28	3.69	0.81				
Model Attitude	27			2.20		- 2.8		deg	
Collective Pitch	29			1.93		4.0		deg	
#1 - Cyclic Pitch	10	3.40	3.10	3.25	0.30	4.0	3.4	deg	
#2 - Cyclic Pitch	11	2.91	2.59	2.75	0.32	1.4	3.7	deg	
#3 - Cyclic Pitch	12	3.20	2.88	3.04	0.32	8.7	3.9	deg	
Gyro Roll Pos.	19	4.65	4.52	4.59	0.13	- 1.3	1.3	deg	
Gyro Pitch Pos.	21	3.99	3.91	3.95	0.08	- 1.5	0.7	deg	
Thrust	33			1.27		254		lb	
Drag	31			1.07		- 9		lb	
Roll Moment	23			3.43		- 34		in-lb	
Pitch Moment	25			2.98		11		in-lb	
Lat. Vibration	28	2.36	1.79		0.57		0.097	fps	
Long. Vibration	30	1.79	1.21		0.58		0.066	fps	
Vert. Vibration	32	1.21	0.50		0.71		0.040	fps	

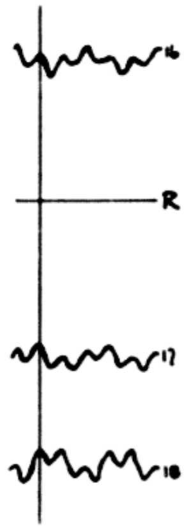


TABLE 15.7 CONFIGURATION E

ITEM n = .27 V_M = 50 MPH	∅ 2170 OSCILLOGRAPH RECORD TR. No.	MAX	MIN	AVE	2A	REDUCED DATA AVE	2A	UNITS	CYC REV.
∅1 - Drag Link	6	2.66	2.58	2.62	0.08	- 99	5	lb	
∅2 - Drag Link	7	2.07	1.82	1.95	0.25	- 123	17	lb	
∅3 - Drag Link	8								
∅1 - Inbd. Flap	13								
∅2 - Inbd. Flap	14	2.28	1.68	1.98	0.60	- 230	600	in-lb	
∅3 - Inbd. Flap	15	1.77	1.41	1.59	0.36	- 323	364	in-lb	
∅1 - Pitch Link	16	1.15	1.03	1.09	0.12	- 36	19	lb	
∅2 - Pitch Link	17	-1.16	-1.27	1.22	0.11	37	16	lb	
∅3 - Pitch Link	18	-1.81	-1.93	1.87	0.12	177	18	lb	
∅1 - Mid Chord	20		5.59						
∅1 - Mid Flap	22	4.13	3.86	4.00	0.27				
∅1 - Mid Torsion	25	3.24	3.15	3.20	0.09				
∅1 - Outbd. Flap	26	3.90	3.59	3.75	0.31				
Model Attitude	27			1.14		- 17		deg	
Collective Pitch	29			1.92		3.9		deg	
∅1 - Cyclic Pitch	10			3.22		3.7		deg	
∅2 - Cyclic Pitch	11	2.74	2.71	3.73	0.03	12.7	0.4	deg	
∅3 - Cyclic Pitch	12	3.03	2.99	3.01	0.04	8.3	0.5	deg	
Gyro Roll Pos.	19	4.71	4.58	4.65	0.13	- 0.7	1.3	deg	
Gyro Pitch Pos.	21	4.08	4.00	4.04	0.08	- 0.8	0.7	deg	
Thrust	33			0.84		86		lb	
Drag	31			1.07		- 9		lb	
Roll Moment	23			3.40		- 42		in-lb	
Pitch Moment	25	2.97	2.89	2.93	0.08	- 7		in-lb	
Lat. Vibration	28	2.20	1.92		0.28		0.047	fps	
Long. Vibration	30	1.80	1.26		0.54		0.062	fps	
Vert. Vibration	32	1.14	0.61		0.53		0.030	fps	

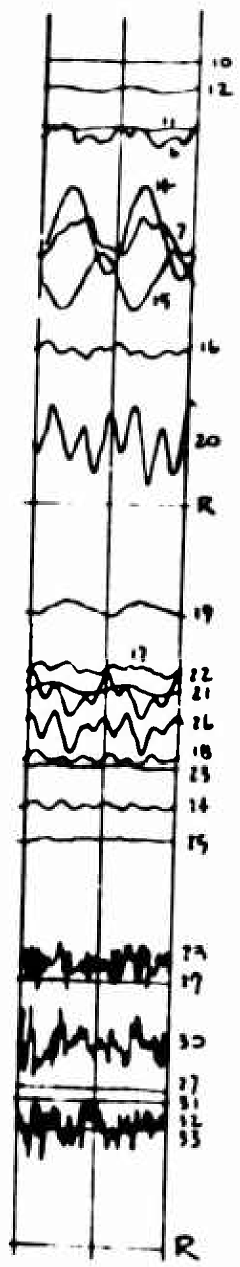


TABLE 15.8 CONFIGURATION I

ITEM n = 1.31 V_H = 50 MPH	TR. No.	ϕ 2172 OSCILLOGRAPH RECORD MAX	MIN	AVE	2A	REDUCED DATA AVE	2A	UNITS	CYC REV.
ϕ1 - Drag Link	6	2.98	2.44	2.71	.54	- 99	32	lb	
ϕ2 - Drag Link	7	2.27	1.74	2.00	0.53	- 120	36	lb	
ϕ3 - Drag Link	8								
ϕ1 - Inbd. Flap	13								
ϕ2 - Inbd. Flap	14	2.34	2.16	2.25	0.18	40	180	in-lb	
ϕ3 - Inbd. Flap	15	1.98	1.74	1.86	0.24	- 51	242	in-lb	
ϕ1 - Pitch Link	16	1.30	1.08	1.19	0.22	- 20	34	lb	
ϕ2 - Pitch Link	17	-.83	-1.07	0.95	0.24	- 3	35	lb	
ϕ3 - Pitch Link	18	-1.29	-1.54	1.41	0.25	107	38	lb	
ϕ1 - Mid Chord	20	6.44	5.23	5.34	0.21	105	25	in-lb	
ϕ1 - Mid Flap	22	4.26	3.85	4.05	0.41				
ϕ1 - Mid Torsion	24	3.27	3.16	3.22	0.11				
ϕ1 - Outbd. Flap	26	3.66	2.92	3.79	0.26				
Model Attitude	27			2.87		5.8		deg	
Collective Pitch	29			1.93		4.0		deg	
ϕ1 - Cyclic Pitch	1	3.50	3.04	3.27	.46	4.2	5.2	deg	
ϕ2 - Cyclic Pitch	11	2.98	2.53	2.76	0.45	1.5	5.2	deg	
ϕ3 - Cyclic Pitch	12	3.27	2.83	3.05	.44	8.8	5.4	deg	
Gyro Roll Pos.	19	4.64	4.52	4.58	.12	- 1.4	1.2	deg	
Gyro Pitch Pos.	21	3.93	3.84	3.89	0.09	- 2.1	0.8	deg	
Thrust	33			1.67		410		lb	
Drag	31			1.92		59		lb	
Roll Moment	23	3.56	3.54	3.55	.02	- 3	5.3	in-lb	
Pitch Moment	25	3.00	[illegible]	2.94	0.13	- 4	4.6	in-lb	
Lat. Vibration	28	2.39	1.79		0.63		0.108	g's	
Long. Vibration	30	1.75	1.19		0.56		0.064	g's	
Vert. Vibration	32	1.19	0.24		0.95		0.054	g's	

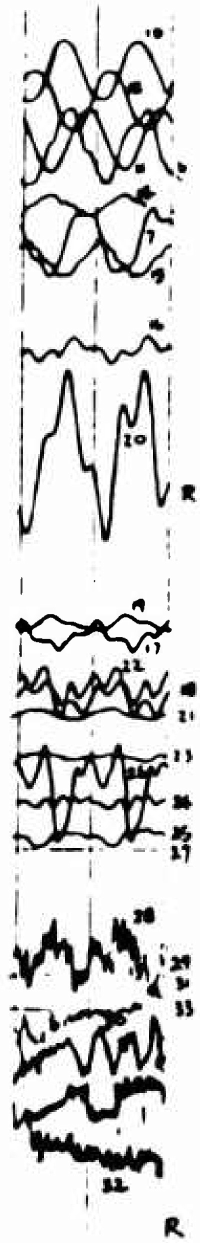


TABLE 15.9 CONFIGURATION E

ITEM n = .88 V_M = 106 MPH	ϕ 2200 OSCILLOGRAPH RECORD					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
ϕ1 - Drag Link	6	2.69	2.26	2.48	0.43	- 106	25	lb	
ϕ2 - Drag Link	7	2.26	1.95	2.11	0.31	- 113	21	lb	
ϕ3 - Drag Link	8								
ϕ1 - Inbd. Flap	13								
ϕ2 - Inbd. Flap	14	2.26	1.95	2.11	0.31	- 100	310	in-lb	
ϕ3 - Inbd. Flap	15	1.91	1.61	1.76	0.30	- 152	303	in-lb	
ϕ1 - Pitch Link	16	1.27	1.93	1.60	0.66	44	103	lb	
ϕ2 - Pitch Link	17	0.74	0.41	0.57	0.33	- 58	48	lb	
ϕ3 - Pitch Link	18	0.59	0.27	0.43	0.32	- 41	48	lb	
ϕ1 - Mid Chord	20	6.49	5.30	5.90	1.19	171	140	lb	
ϕ1 - Mid Flap	22	4.43	3.87	4.15	0.56				
ϕ1 - Mid Torsion	24	3.37	3.06	3.22	0.31				
ϕ1 - Outbd. Flap	26	3.14	2.43	2.81	0.66				
Model Attitude	27			1.94		- 6.3		deg	
Collective Pitch	29			2.13		6.3		deg	
ϕ1 - Cyclic Pitch	10	3.84	3.20	3.52	0.64	7.1	7.3	deg	
ϕ2 - Cyclic Pitch	11	3.52	2.89	3.20	0.63	6.6	7.3	deg	
ϕ3 - Cyclic Pitch	12	3.25	2.67	2.96	0.58	7.8	7.1	deg	
Gyro Roll Pos.	19	4.74	4.65	4.70	0.09	- 0.2	0.9	deg	
Gyro Pitch Pos.	21	3.84	3.79	3.81	0.09	- 2.8	0.5	deg	
Thrust	33			1.33		276		lb	
Drag	31			1.09		- 7		lb	
Roll Moment	23			3.77		55		in-lb	
Pitch Moment	25			2.93		- 7		in-lb	
Lat. Vibration	28	2.21	1.75		0.46		0.079	fps	
Long. Vibration	30	1.68	1.29		0.39		0.044	fps	
Vert. Vibration	32	1.29	0.57		0.72		0.041	fps	

TABLE 15.10 CONFIGURATION E

n = .3 V_M = 106 MPH	#2202 OSCILLOGRAPH RECORD					REDUCED DATA			
ITEM	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link	6	2.62	2.35	2.49	0.27	-112	16	lb	
#2 - Drag Link	7	2.24	1.98	2.11	0.26	-113	17	lb	
#3 - Drag Link	8								
#1 - Inbd. Flap	13								
#2 - Inbd. Flap	14	2.24	1.73	1.99	0.51	-220	510	in-lb	
#3 - Inbd. Flap	15	1.73	1.50	1.62	0.23	-293	232	in-lb	
#1 - Pitch Link	16	1.18	0.89	1.04	0.29	-44	45	lb	
#2 - Pitch Link	17	0.58	0.37	0.48	0.21	-72	31	lb	
#3 - Pitch Link	18	0.44	0.19	0.31	0.25	-59	38	lb	
#1 - Mid Chord	20	6.34	5.51	5.93	0.83	175	98	in-lb	
#1 - Mid Flap	22	4.33	3.86	4.10	0.47				
#1 - Mid Torsion	24	3.29	3.08	3.19	0.21				
#1 - Outbd. Flap	26	3.29	2.72	3.00	0.57				
Model Attitude	27			1.51		-12.1		deg	
Collective Pitch	29			2.13		6.3		deg	
#1 - Cyclic Pitch	10	3.70	3.31	3.51	0.39	6.9	4.4	deg	
#2 - Cyclic Pitch	11	3.39	2.98	3.19	0.41	6.3	4.8	deg	
#3 - Cyclic Pitch	12	3.12	2.74	2.93	0.38	7.3	4.6	deg	
Gyro Roll Pos.	19			4.70		-0.2		deg	
Gyro Pitch Pos.	21			3.91		-1.9		deg	
Thrust	33			0.86		94		lb	
Drag	31			1.09		-7		lb	
Roll Moment	23			3.55		-3		in-lb	
Pitch Moment	25			2.85		-36		in-lb	
Lat. Vibration	28	2.14	1.77		0.37		0.063	fps	
Long. Vibration	30	1.72	1.25		0.47		0.054	fps	
Vert. Vibration	32	1.20	0.51		0.69		0.039	fps	

TABLE 15.11 CONFIGURATION B

μ = 1.25 V_H = 106 MPH ITEM	#2204 OSCILLOGRAPH RECORD					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link	6	2.74	2.22	2.4[illegible]	0.52	-107	31	lb	
#2 - Drag Link	7	2.51	1.87	2.19	0.64	-107	43	lb	
#3 - Drag Link	8								
#1 - Inbd. Flap	13								
#2 - Inbd. Flap	14	2.51	1.97	2.24	0.54	30	540	in-lb	
#3 - Inbd. Flap	15	2.01	1.69	1.85	0.32	- 66	323	in-lb	
#1 - Pitch Link	16	1.26	0.96	1.11	0.30	- 33	47	lb	
#2 - Pitch Link	17	0.67	0.42	0.55	0.25	- 61	37	lb	
#3 - Pitch Link	18	0.51	0.20	0.36	0.31	- 51	47	lb	
#1 - Mid Chord	20	6.47	5.26	5.87	1.21	168	143	in-lb	
#1 - Mid Flap	22	4.47	3.90	4.19	0.59				
#1 - Mid Torsion	24	3.42	3.09	3.26	0.33				
#1 - Outbd. Flap	26	2.98	2.18	2.58	0.80				
Model Attitude	27			2.73		-2.4		deg	
Collective Pitch	29			2.1[illegible]		6.3		deg	
#1 - Cyclic Pitch	10	3.94	3.14	3.54	0.80	7.3	9.1	deg	
#2 - Cyclic Pitch	11	3.62	2.84	3.23	0.78	7.0	9.0	deg	
#3 - Cyclic Pitch	12	3.32	2.57	2.95	0.75	7.6	9.2	deg	
Gyro Roll Pos.	19	4.76	4.69	4.72	0.07	0	0.7	deg	
Gyro Pitch Pos.	21	3.78	3.72	3.75	0.06	-3.3	0.5	deg	
Thrust	33			1.63		394		lb	
Drag	31			1.39		17		lb	
Roll Moment	23			[illegible].69		34		in-lb	
Pitch Moment	25			[illegible].35		215		in-lb	
Lat. Vibration	28	2.34	1.69		0.65		0.211	fps	
Long. Vibration	30	1.87	1.24		0.63		0.072	fps	
Vert. Vibration	32	1.24	0.47		0.77		0.044	fps	

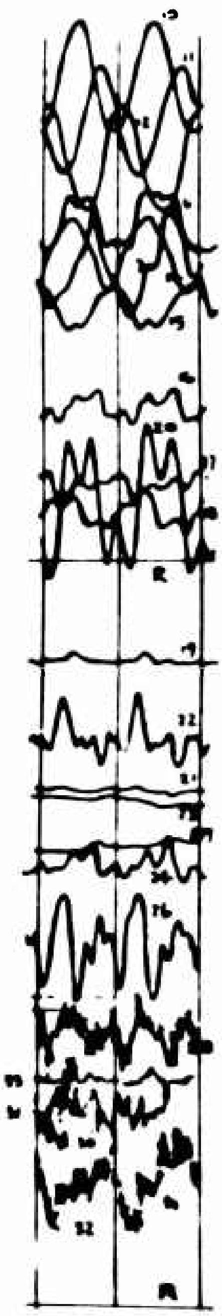


TABLE 15.12 CONFIGURATION B

n = 1.72 V_H = 106 MPH ITEM	#206 OSCILLOGRAPH RECORD TR. No.	MAX	MIN	AVE	2A	REDUCED DATA AVE	2A	UNITS	CYC REV.
Ø1 - Drag Link	6	2.85	2.20	2.53	0.65	-104	38	lb	
Ø2 - Drag Link	7	2.51	1.79	2.15	0.72	-110	48	lb	
Ø3 - Drag Link	8								
Ø1 - Inbd. Flap	13								
Ø2 - Inbd. Flap	14	2.47	2.15	2.31	0.32	100	320	in-lb	
Ø3 - Inbd. Flap	15	2.15	1.79	1.97	0.36	61	364	in-lb	
Ø1 - Pitch Link	16	1.29	0.97	1.13	0.32	- 30	50	lb	
Ø2 - Pitch Link	17	0.66	0.39	0.53	0.27	- 64	39	lb	
Ø3 - Pitch Link	18	0.52	0.22	0.37	0.30	- 50	45	lb	
Ø1 - Mid Chord	20	6.53	5.17	5.89	1.36	165	160	in-lb	
Ø1 - Mid Flap	22	4.51	3.96	4.24	0.55				
Ø1 - Mid Torsion	24	3.41	3.12	3.27	0.29				
Ø1 - Outbd. Flap	26	2.86	1.95	2.40	0.91				
Model Attitude				2.52		1.5		deg	
Collective Pitch				2.12		6.2		deg	
Ø1 - Cyclic Pitch	10	4.02	3.10	3.56	0.92	7.5	10.5	deg	
Ø2 - Cyclic Pitch	11	3.68	2.79	3.24	0.89	7.1	10.3	deg	
Ø3 - Cyclic Pitch	12	3.39	2.51	2.95	0.88	7.6	10.6	deg	
Gyro Roll Pos.	19	4.74	4.65	4.70	0.09	-0.2	0.9	deg	
Gyro Pitch Pos.	21	3.72	3.66	3.69	0.06	-3.9	0.5	deg	
Thrust	33			2.00		539		lb	
Drag	31			1.84		53		lb	
Roll Moment	23			3.42		- 37		in-lb	
Pitch Moment	25	2.97	2.91	2.94	0.06	- 4	2	in-lb	
Lat. Vibration	28	2.23	1.69		0.54		0.092	fps	
Long. Vibration	30	1.69	1.24		0.45		0.051	fps	
Vert. Vibration	32	1.24	0.54		0.70		0.740	fps	

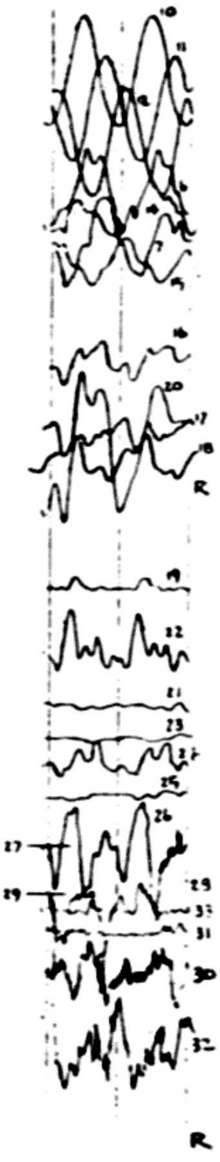


TABLE 14.1 CONFIGURATION F

μ = .00 V_H = 0 MPH ITEM	8397 OSCILLOGRAPH RECORD TR. No.	MAX	MIN	AVE	2A	REDUCED DATA AVE	2A	UNITS	CYC REV.
Ø1 - Drag Link	6						17	lb	1
Ø2 - Drag Link	7						23	lb	1
Ø3 - Drag Link	8								
Ø1 - Inbd. Flap	13								
Ø2 - Inbd. Flap	14						80	in-lb	1
Ø3 - Inbd. Flap	15						90	in-lb	1
Ø1 - Pitch Link	16						12	lb	
Ø2 - Pitch Link	17						54	lb	1
Ø3 - Pitch Link	18								
Ø1 - Mid Chord	20								
Ø1 - Mid Flap	22								
Ø1 - Mid Torsion	24						60	in-lb	
Ø1 - Outbd. Flap	26								
Model Attitude	27					.40		deg	
Collective Pitch	29								
Ø1 - Cyclic Pitch	10								
Ø2 - Cyclic Pitch	11								
Ø3 - Cyclic Pitch	12								
Gyro Roll Pos.	19								
Gyro Pitch Pos.	21								
Thrust	33					270		lb	
Drag	31								
Roll Moment	23								
Pitch Moment	25								
Lat. Vibration	28						.046	fps	
Long. Vibration	30						.036	fps	
Vert. Vibration	32						.018	fps	

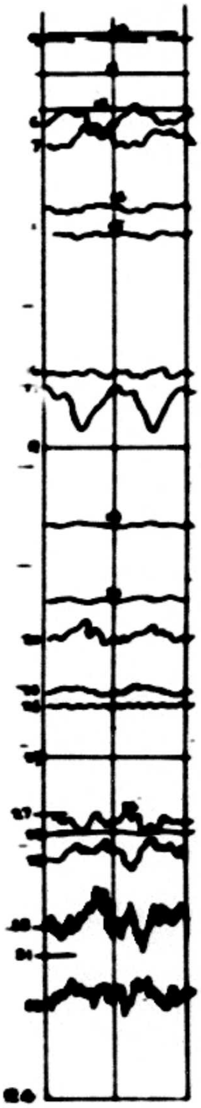


TABLE 16.2 CONFIGURATION F

n = 1.37 V_H = 0 MPH ITEM	TR. No.	OSCILLOGRAPH RECORD R395 MAX	MIN	AVE	2A	REDUCED DATA AVE	2A	UNITS	CYC REV.
Ø1 - Drag Link	6						48	lb	1
Ø2 - Drag Link	7						37	lb	
Ø3 - Drag Link	8								
Ø1 - Inbd. Flap	13								
Ø2 - Inbd. Flap	14						44.4	in-lb	1
Ø3 - Inbd. Flap	15						140	in-lb	1
Ø1 - Pitch Link	16						28	lb	
Ø2 - Pitch Link	17						75	lb	1
Ø3 - Pitch Link	18								
Ø1 - Mid Chord	20								
Ø1 - Mid Flap	22								
Ø1 - Mid Torsion	24						75	in-lb	
Ø1 - Outbd. Flap	26								
Model Attitude	27					.2		deg	
Collective Pitch	29								
Ø1 - Cyclic Pitch	10								
Ø2 - Cyclic Pitch	11								
Ø3 - Cyclic Pitch	12								
Gyro Roll Pos.	19								
Gyro Pitch Pos.	21								
Thrust	33					430		lb	
Drag	31								
Roll Moment	23								
Pitch Moment	25								
Lat. Vibration	28						.128	fps	2
Long. Vibration	30						.067	fps	2
Vert. Vibration	32						.040	fps	2

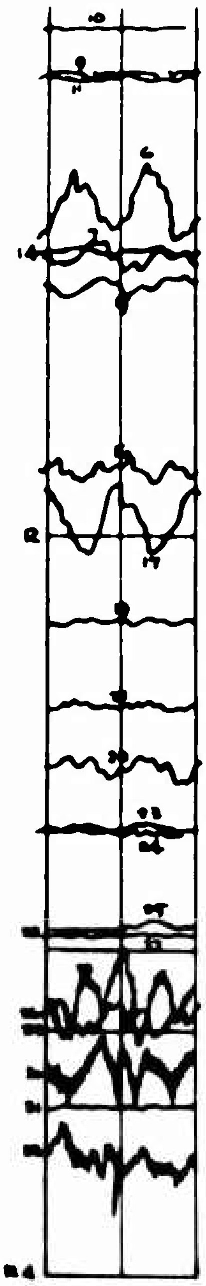


TABLE 16.3 CONFIGURATION 7

a = .95 V_H = 85 MPH ITEM	TR. No.	#1600 OSCILLOGRAPH RECORD MAX	MIN	AVE	2A	REDUCED DATA AVE	2A	UNITS	CYC REV.
#1 - Drag Link	6						75	lb	1
#2 - Drag Link	7						104	lb	1
#3 - Drag Link	8								
#1 - Inbd. Flap	13								
#2 - Inbd. Flap	14						389	in-lb	1
#3 - Inbd. Flap	15						350	in-lb	1
#1 - Pitch Link	16						44	lb	1 & 3
#2 - Pitch Link	17						50	lb	1 & 3
#3 - Pitch Link	18								
#1 - Mid Chord	20								
#1 - Mid Flap	22								
#1 - Mid Torsion	24						60	in-lb	
#1 - Outbd. Flap	26								
Model Attitude	27					-.98		deg	
Collective Pitch	29								
#1 - Cyclic Pitch	10								
#2 - Cyclic Pitch	11								
#3 - Cyclic Pitch	12								
Gyro Roll Pos.	19								
Gyro Pitch Pos.	21								
Thrust	33					300		lb	
Drag	31								
Roll Moment	23								
Pitch Moment	25								
Lat. Vibration	28						.086	fps	
Long. Vibration	30						.034	fps	
Vert. Vibration	32						.025	fps	

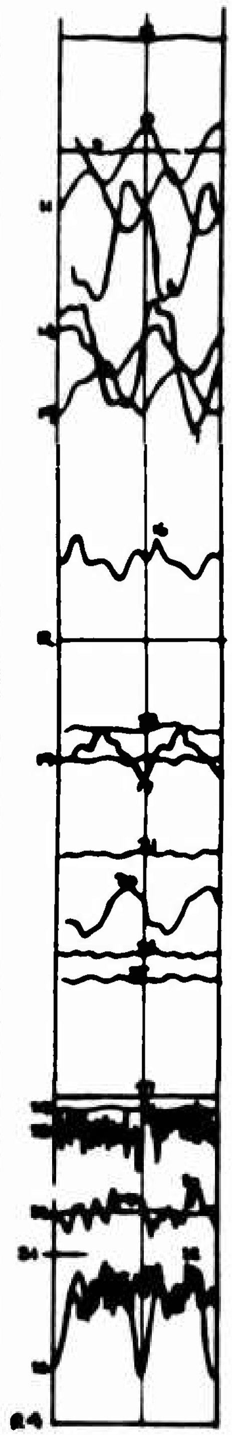


TABLE 16.4 CONFIGURATION F

μ = .81 V_H = 25 MPH ITEM	TR. No.	#7603 OSCILLOGRAPH RECORD MAX	MIN	AVE	2A	REDUCED DATA AVE	2A	UNITS	CYC REV.
#1 - Drag Link	6						51	lb	1
#2 - Drag Link	7						72	lb	1
#3 - Drag Link	8								
#1 - Inbd. Flap	13								
#2 - Inbd. Flap	14						266	in-lb	1
#3 - Inbd. Flap	15						300	in-lb	1
#1 - Pitch Link	16						26	lb	
#2 - Pitch Link	17								1
#3 - Pitch Link	18								
#1 - Mid Chord	20								
#1 - Mid Flap	22								
#1 - Mid Torsion	24						30	in-lb	
#1 - Outbd. Flap	26								
Model Attitude	27					- 17.1		deg	
Collective Pitch	29								
#1 - Cyclic Pitch	10								
#2 - Cyclic Pitch	11								
#3 - Cyclic Pitch	12								
Gyro Roll Pos.	19								
Gyro Pitch Pos.	21								
Thrust	33					[illegible]		lb	
Drag	31								
Roll Moment	23								
Pitch Moment	25								
Lat. Vibration	28						.099	fps	
Long. Vibration	30						.039	fps	
Vert. Vibration	32						.035	fps	

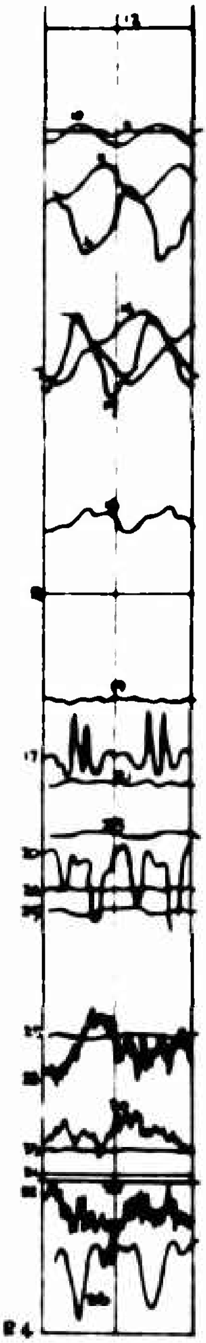


TABLE 16.5 CONFIGURATION F

μ = 1.11 V_N = 25 MPH ITEM	[illegible] OSCILLOGRAPH RECORD					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
ϕ1 - Drag Link	6						106	lb	1
ϕ2 - Drag Link	7						169	lb	1
ϕ3 - Drag Link	8								
ϕ1 - Inbd. Flap	13								
ϕ2 - Inbd. Flap	14						534	in-lb	1
ϕ3 - Inbd. Flap	15						500	in-lb	1
ϕ1 - Pitch Link	16						61	lb	1 & 3
ϕ2 - Pitch Link	17						64	lb	1 & 3
ϕ3 - Pitch Link	18								
ϕ1 - Mid Chord	20								
ϕ1 - Mid Flap	22								
ϕ1 - Mid Torsion	24						75	in-lb	
ϕ1 - Outbd. Flap	26								
Model Attitude	27					9.1		deg	
Collective Pitch	29								
ϕ1 - Cyclic Pitch	10								
ϕ2 - Cyclic Pitch	11								
ϕ3 - Cyclic Pitch	12								
Gyro Roll Pos.	19								
Gyro Pitch Pos.	21								
Thrust	33					350		lb	
Drag	31								
Roll Moment	23								
Pitch Moment	25								
Lat. Vibration	28						.075	fps	
Long. Vibration	30						.071	fps	
Vert. Vibration	32						.025	fps	

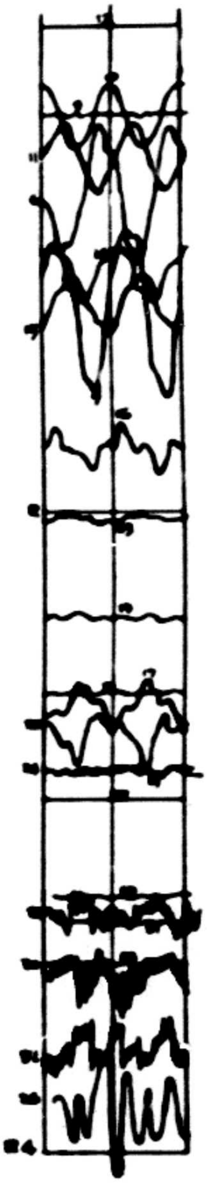


TABLE 16.6 CONFIGURATION F

n = .89 V_N = 50 MPH ITEM	R409 OSCILLOGRAPH RECORD					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link	6						45	lb	1
#2 - Drag Link	7						64	lb	1
#3 - Drag Link	8								
#1 - Inbd. Flap	13						244	in-lb	1
#2 - Inbd. Flap	14						160	in-lb	1
#3 - Inbd. Flap	15								
#1 - Pitch Link	16						42	lb	1 & 3
#2 - Pitch Link	17						44	lb	1 & 3
#3 - Pitch Link	18								
#1 - Mid Chord	20								
#1 - Mid Flap	22								
#1 - Mid Torsion	24								
#1 - Outbd. Flap	26								
Model Attitude	27								
Collective Pitch	29								
#1 - Cyclic Pitch	10								
#2 - Cyclic Pitch	11								
#3 - Cyclic Pitch	12								
Gyro Roll Pos.	19								
Gyro Pitch Pos.	21								
Thrust	33					281		lb	
Drag	31								
Roll Moment	23								
Pitch Moment	25								
Lat. Vibration	28						.074	fps	2
Long. Vibration	30						.071	fps	2
Vert. Vibration	32						.031	fps	2

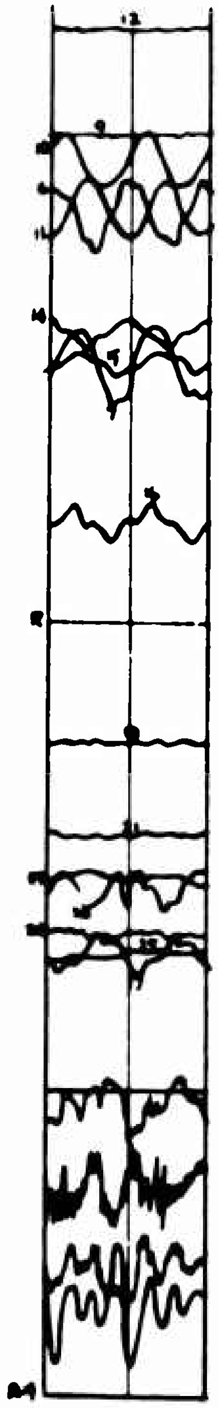


TABLE 16.7 CONFIGURATION F

n = .45 V_M = 50 MPH ITEM	TR. No.	#2412 OSCILLOGRAPH RECORD MAX	MIN	AVE	2A	REDUCED DATA AVE	2A	UNITS	CYC REV.
φ1 - Drag Link	6						25	lb	1
φ2 - Drag Link	7						53	lb	1
φ3 - Drag Link	8								
φ1 - Inbd. Flap	13								
φ2 - Inbd. Flap	14						511	in-lb	1
φ3 - Inbd. Flap	15						411	in-lb	1
φ1 - Pitch Link	16						10		1
φ2 - Pitch Link	17						21		1
φ3 - Pitch Link	18								
φ1 - Mid Chord	20								
φ1 - Mid Flap	22								
φ1 - Mid Torsion	24								
φ1 - Outbd. Flap	26								
Model Attitude	27					-17		deg	
Collective Pitch	29								
φ1 - Cyclic Pitch	10								
φ2 - Cyclic Pitch	11								
φ3 - Cyclic Pitch	12								
Gyro Roll Pos.	19								
Gyro Pitch Pos.	21								
Thrust	33					142		lb	
Drag	31								
Roll Moment	23								
Pitch Moment	25								
Lat. Vibration	28						.072	fps	
Long. Vibration	30						.045	fps	
Vert. Vibration	32						.025	fps	

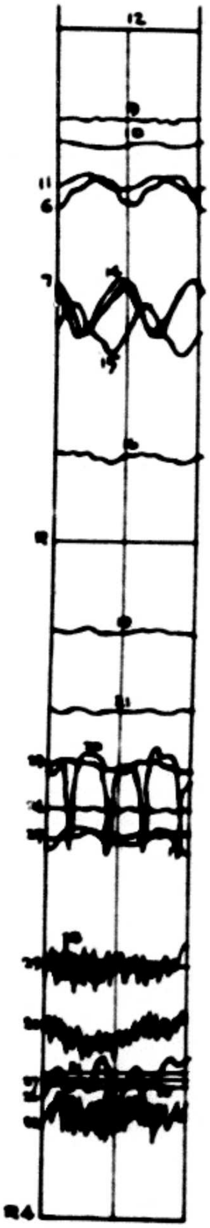


TABLE 16.8 CONFIGURATION F

n = 1.23 V_M = 50 MPH ITEM	#2415 OSCILLOGRAPH RECORD					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link #2 - Drag Link #3 - Drag Link	6 7 8						82 109	lb lb	1 1
#1 - Inbd. Flap #2 - Inbd. Flap #3 - Inbd. Flap	13 14 15						256 260	in-lb in-lb	1 1
#1 - Pitch Link #2 - Pitch Link #3 - Pitch Link	16 17 18						37 37	lb lb	1 & 3 1 & 3
#1 - Mid Chord #1 - Mid Flap #1 - Mid Torsion #1 - Outbd. Flap	20 22 24 26						60	in-lb	
Model Attitude Collective Pitch #1 - Cyclic Pitch #2 - Cyclic Pitch #3 - Cyclic Pitch	27 29 10 11 12					6.85		deg	
Gyro Roll Pos. Gyro Pitch Pos.	19 21								
Thrust Drag Roll Moment Pitch Moment	33 31 23 25					385		lb	
Lat. Vibration Long. Vibration Vert. Vibration	28 30 32						.085 .073 .018	fps fps fps	2

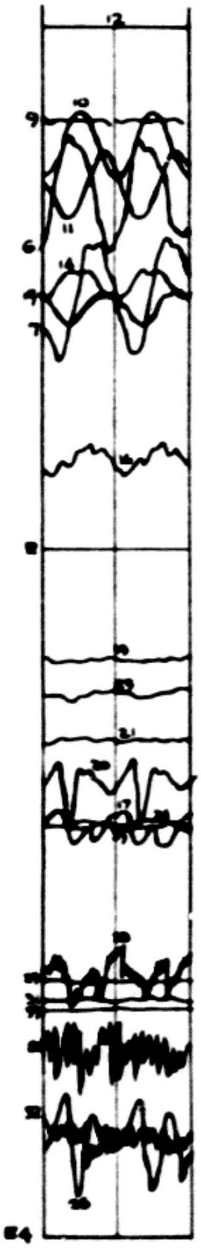


TABLE 16.9 CONFIGURATION F

n = .81 V_M = 106 MPH ITEM	#2418 OSCILLOGRAPH RECORD TR. No.	MAX	MIN	AVE	2A	REDUCED DATA AVE	2A	UNITS	CYC REV.
#1 - Drag Link	6						42	lb	1
#2 - Drag Link	7						69	lb	1
#3 - Drag Link	8								
#1 - Inbd. Flap	13								
#2 - Inbd. Flap	14						378	in-lb	1
#3 - Inbd. Flap	15						220	lb	1
#1 - Pitch Link	16						40	lb	1 & 3
#2 - Pitch Link	17						54	lb	1 & 3
#3 - Pitch Link	18								
#1 - Mid Chord	20								
#1 - Mid Flap	22								
#1 - Mid Torsion	24						75	in-lb	
#1 - Outbd. Flap	26								
Model Attitude	27					-6.58		deg	
Collective Pitch	29								
#1 - Cyclic Pitch	10								
#2 - Cyclic Pitch	11								
#3 - Cyclic Pitch	12								
Gyro Roll Pos.	19								
Gyro Pitch Pos.	21								
Thrust	33					256		lb	
Drag	31								
Roll Moment	23								
Pitch Moment	25								
Lat. Vibration	28						.068	fps	
Long. Vibration	30						.065	fps	
Vert. Vibration	32						.015	fps	

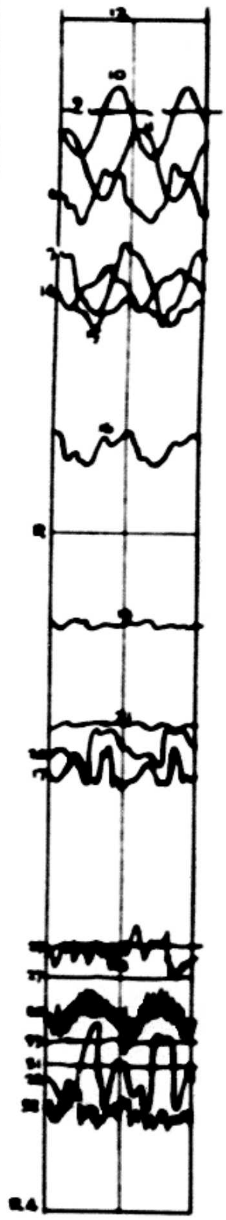


TABLE 16.20 CONFIGURATION F

μ = .39 V_N = 106 MPH ITEM	TR. No.	OSCILLOGRAPH RECORD #2421 MAX	MIN	AVE	2A	REDUCED DATA AVE	2A	UNITS	CYC REV.
ϕ1 - Drag Link	6						12	lb	1
ϕ2 - Drag Link	7						22	lb	1
ϕ3 - Drag Link	8								
ϕ1 - Inbd. Flap	13						455	in-lb	1
ϕ2 - Inbd. Flap	14						340	in-lb	1
ϕ3 - Inbd. Flap	15								
ϕ1 - Pitch Link	16						28	lb	1 & 3
ϕ2 - Pitch Link	17							lb	
ϕ3 - Pitch Link	18								
ϕ1 - Mid Chord	20								
ϕ1 - Mid Flap	22								
ϕ1 - Mid Torsion	24						60	in-lb	
ϕ1 - Outbd. Flap	26								
Model Attitude	27					-12.2		deg	
Collective Pitch	29								
ϕ1 - Cyclic Pitch	10								
ϕ2 - Cyclic Pitch	11								
ϕ3 - Cyclic Pitch	12								
Gyro Roll Pos.	19								
Gyro Pitch Pos.	21								
Thrust	33					123		lb	
Drag	31								
Roll Moment	23								
Pitch Moment	25								
Lat. Vibration	28						.051	fps	
Long. Vibration	30						.088	fps	
Vert. Vibration	32						.042	fps	

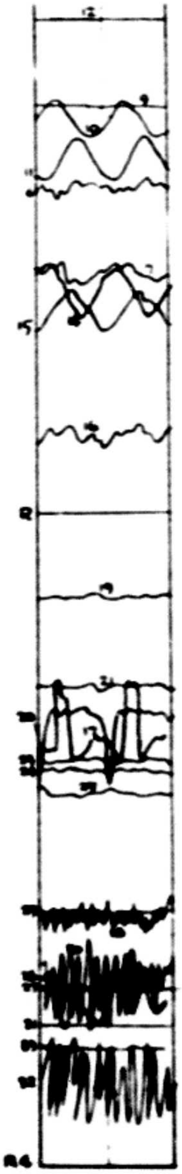


TABLE 16.11 CONFIGURATION F

μ = 1.13 V_M = 106 MPH ITEM	#2424 OSCILLOGRAPH RECORD					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
Ø1 - Drag Link	6						68	lb	1
Ø2 - Drag Link	7						100	lb	1
Ø3 - Drag Link	8								
Ø1 - Inbd. Flap	13								
Ø2 - Inbd. Flap	14						500	in-lb	1
Ø3 - Inbd. Flap	15						310	in-lb	1
Ø1 - Pitch Link	16						44	lb	1&3
Ø2 - Pitch Link	17						50	lb	1&3
Ø3 - Pitch Link	18								
Ø1 - Mid Chord	20								
Ø1 - Mid Flap	22								
Ø1 - Mid Torsion	24						120	in-lb	4
Ø1 - Outbd. Flap	26								
Model Attitude	27					-1.12		deg	
Collective Pitch	29								
Ø1 - Cyclic Pitch	10								
Ø2 - Cyclic Pitch	11								
Ø3 - Cyclic Pitch	12								
Gyro Roll Pos.	19								
Gyro Pitch Pos.	21								
Thrust	33					354		lb	
Drag	31								
Roll Moment	23								
Pitch Moment	25								
Lat. Vibration	28						.067	fps	2
Long. Vibration	30						.097	fps	
Vert. Vibration	32						.029	fps	

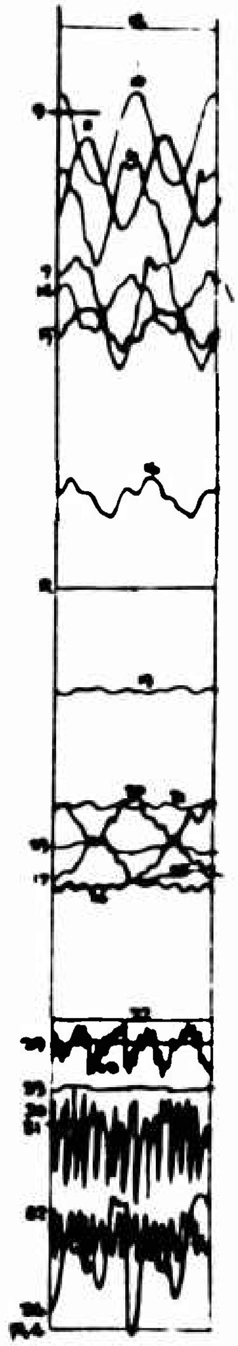


TABLE 16.12 CONFIGURATION F

a = 1.9 V_H = 106 MPH ITEM	#2427 OSCILLOGRAPH RECORD					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link	6						123	lb	1
#2 - Drag Link	7						169	lb	1
#3 - Drag Link	8								
#1 - Inbd. Flap	13								
#2 - Inbd. Flap	14						578	in-lb	1
#3 - Inbd. Flap	15						410	in-lb	1
#1 - Pitch Link	16						54	lb	1&3
#2 - Pitch Link	17								
#3 - Pitch Link	18								
#1 - Mid Chord	20								
#1 - Mid Flap	22								
#1 - Mid Torsion	24								
#1 - Outbd. Flap	26								
Model Attitude	27					3.92		deg	
Collective Pitch	29								
#1 - Cyclic Pitch	10								
#2 - Cyclic Pitch	11								
#3 - Cyclic Pitch	12								
Gyro Roll Pos.	19								
Gyro Pitch Pos.	21								
Thrust	33					596		lb	
Drag	31								
Roll Moment	23								
Pitch Moment	25								
Lat. Vibration	28						.103	fps	2
Long. Vibration	30						.019	fps	
Vert. Vibration	32						.046	fps	2

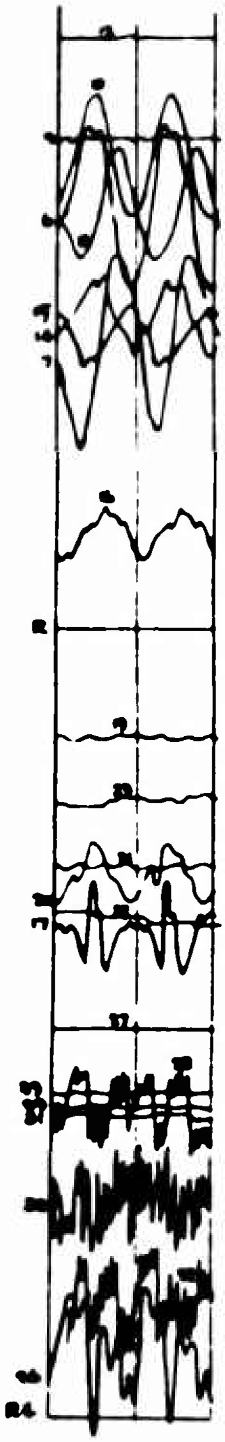


TABLE 17.1 CONFIGURATION 0

μ = .41 V_H = 0 MPH ITEM	[illegible] OSCILLOGRAPH RECORD					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
ϕ1 - Drag Link	6						32	lb	1
ϕ2 - Drag Link	7						35	lb	1
ϕ3 - Drag Link	8								
ϕ1 - Inbd. Flap	13								
ϕ2 - Inbd. Flap	14						111	in-lb	1
ϕ3 - Inbd. Flap	15						300	in-lb	1
ϕ1 - Pitch Link	16						12	lb	
ϕ2 - Pitch Link	17						11	lb	
ϕ3 - Pitch Link	18								
ϕ1 - Mid Chord	20								
ϕ1 - Mid Flap	22								
ϕ1 - Mid Torsion	24						15	in-lb	
ϕ1 - Outbd. Flap	26								
Model Attitude	27					0.1		deg	
Collective Pitch	29								
ϕ1 - Cyclic Pitch	10						0.25	deg	
ϕ2 - Cyclic Pitch	11						0.25	deg	
ϕ3 - Cyclic Pitch	12						0.25	deg	
Gyro Roll Pos.	19								
Gyro Pitch Pos.	21								
Thrust	33					192		lb	
Drag	31								
Roll Moment	23								
Pitch Moment	25								
Lat. Vibration	28						.065	fps	
Long. Vibration	30						.042	fps	
Vert. Vibration	32						.028	fps	

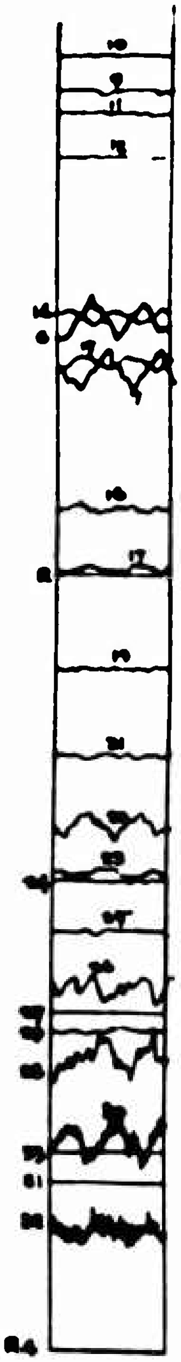


TABLE 17.2 CONFIGURATION G

n = 1.31 V_H = 0 MPH ITEM	TR. No.	#2445 OSCILLOGRAPH RECORD MAX	MIN	AVE	2A	REDUCED DATA AVE	2A	UNITS	CYC REV.
#1 - Drag Link #2 - Drag Link #3 - Drag Link	6 7 8						64 75	lb lb	
#1 - Inbd. Flap #2 - Inbd. Flap #3 - Inbd. Flap	13 14 15						 111 110	 in-lb in-lb	
#1 - Pitch Link #2 - Pitch Link #3 - Pitch Link	16 17 18						32 27	lb lb	144 144
#1 - Mid Chord #1 - Mid Flap #1 - Mid Torsion #1 - Outbd. Flap	20 22 24 26						 105	 lb	
Model Attitude Collective Pitch #1 - Cyclic Pitch #2 - Cyclic Pitch #3 - Cyclic Pitch	27 29 10 11 12					0	 0.5 0.6 0.9	deg deg deg deg	 1 1 1
Gyro Roll Pos. Gyro Pitch Pos.	19 21								
Thrust Drag Roll Moment Pitch Moment	33 34 23 25					411		lb	
Lat. Vibration Long. Vibration Vert. Vibration	28 30 32						.134 .067 .047	fps fps fps	

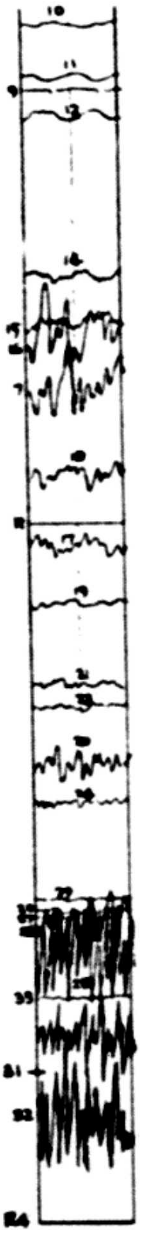


TABLE 17.3 CONFIGURATION G

n = .97 V_M = 25 MPH ITEM	#2456 OSCILLOGRAPH RECORD					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link	6						80	lb	1
#2 - Drag Link	7						126	lb	1
#3 - Drag Link	8								
#1 - Inbd. Flap	13								
#2 - Inbd. Flap	14						355	in-lb	1
#3 - Inbd. Flap	15						380	in-lb	1
#1 - Pitch Link	16						48	lb	1&3
#2 - Pitch Link	17						41	lb	1&3
#3 - Pitch Link	18								
#1 - Mid Chord	20								
#1 - Mid Flap	22								
#1 - Mid Torsion	24						75	lb	
#1 - Outbd. Flap	26								
Model Attitude	27					-.84		deg	
Collective Pitch	29								
#1 - Cyclic Pitch	10						3	deg	1
#2 - Cyclic Pitch	11						5	deg	1
#3 - Cyclic Pitch	12						5	deg	1
Gyro Roll Pos.	19								
Gyro Pitch Pos.	21								
Thrust	33					304		lb	
Drag	31								
Roll Moment	23								
Pitch Moment	25								
Lat. Vibration	28						.091	fps	
Long. Vibration	30						.047	fps	
Vert. Vibration	32						.038	fps	3

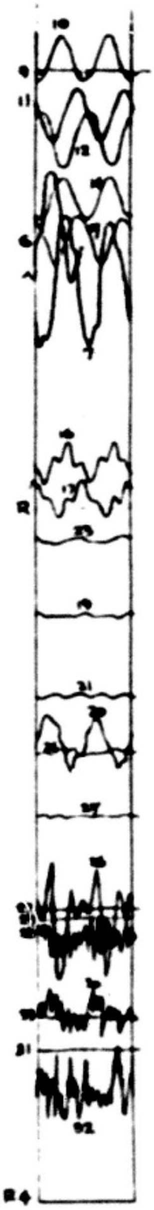


TABLE 17.4 CONFIGURATION G

n = 1.09 V_M = 25 MPH ITEM	#2462 OSCILLOGRAPH RECORD					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
ø1 - Drag Link	6						99	lb	1
ø2 - Drag Link	7						139	lb	1
ø3 - Drag Link	8								
ø1 - Inbd. Flap	13								
ø2 - Inbd. Flap	14						577	in-lb	1
ø3 - Inbd. Flap	15						620	in-lb	1
ø1 - Pitch Link	16						65	lb	1&3
ø2 - Pitch Link	17						68	lb	1&3
ø3 - Pitch Link	18								
ø1 - Mid Chord	20								
ø1 - Mid Flap	22								
ø1 - Mid Torsion	24						72	in-lb	
ø1 - Outbd. Flap	26								
Model Attitude	27					8.7		deg	
Collective Pitch	29								
ø1 - Cyclic Pitch	10						6	deg	1
ø2 - Cyclic Pitch	11						7	deg	1
ø3 - Cyclic Pitch	12						7	deg	1
Gyro Roll Pos.	19								
Gyro Pitch Pos.	21								
Thrust	33					342		lb	
Drag	31								
Roll Moment	23								
Pitch Moment	25								
Lat. Vibration	28						.072	fps	
Long. Vibration	30						.034	fps	
Vert. Vibration	32						.050	fps	3

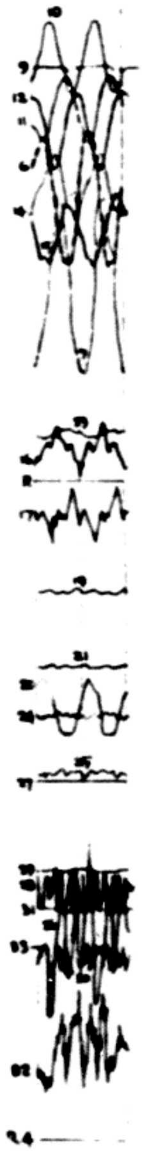


TABLE 17.5 CONFIGURATION G

n = .78 V_M = 25 MPH ITEM	#2459 OSCILLOGRAPH RECORD					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
ϕ1 - Drag Link	6						52	lb	1
ϕ2 - Drag Link	7						75	lb	1
ϕ3 - Drag Link	8								1
ϕ1 - Inbd. Flap	13								
ϕ2 - Inbd. Flap	14						355	in-lb	1
ϕ3 - Inbd. Flap	15						340	in-lb	1
ϕ1 - Pitch Link	16						32	lb	1
ϕ2 - Pitch Link	17						31	lb	1
ϕ3 - Pitch Link	18								
ϕ1 - Mid Chord	20								
ϕ1 - Mid Flap	22								
ϕ1 - Mid Torsion	24						30	lb	
ϕ1 - Outbd. Flap	26								
Model Attitude	27					-17.2		deg	
Collective Pitch	29								
ϕ1 - Cyclic Pitch	10						1	deg	1
ϕ2 - Cyclic Pitch	11						2	deg	1
ϕ3 - Cyclic Pitch	12						2	deg	1
Gyro Roll Pos.	19								
Gyro Pitch Pos.	21								
Thrust	33					266		lb	
Drag	31								
Roll Moment	23								
Pitch Moment	25								
Lat. Vibration	28						.123	fps	
Long. Vibration	30						.043	fps	
Vert. Vibration	32						.040	fps	

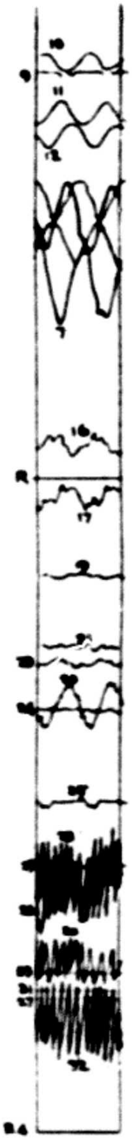


TABLE 17.6   CONFIGURATION O

n = .94 V_H = 50 MPH ITEM	#2465 OSCILLOGRAPH RECORD					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link	6						90	lb	1
#2 - Drag Link	7						100	lb	1
#3 - Drag Link	8								
#1 - Inbd. Flap	13								
#2 - Inbd. Flap	14						322	in-lb	1
#3 - Inbd. Flap	15						240	in-lb	1
#1 - Pitch Link	16						44	lb	1&3
#2 - Pitch Link	17						55	lb	1&3
#3 - Pitch Link	18								
#1 - Mid Chord	20								
#1 - Mid Flap	22								
#1 - Mid Torsion	24						30	in-lb	
#1 - Outbd. Flap	26								
Model Attitude	27					-2.8		deg	
Collective Pitch	29								
#1 - Cyclic Pitch	10						4	deg	1
#2 - Cyclic Pitch	11						5	deg	1
#3 - Cyclic Pitch	12						5	deg	1
Gyro Roll Pos.	19								
Gyro Pitch Pos.	21								
Thrust	33					296		lb	
Drag	31								
Roll Moment	23								
Pitch Moment	25								
Lat. Vibration	28						.108	fps	
Long. Vibration	30						.035	fps	
Vert. Vibration	32						.050	fps	

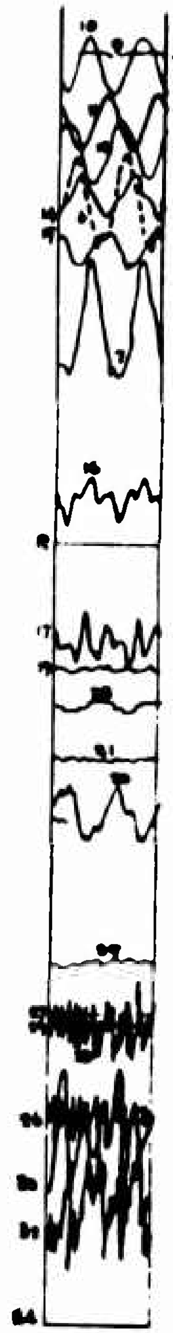


TABLE 17.7 CONFIGURATION 0

μ = .43 V_M = 50 MPH ITEM	TR. No.	OSCILLOGRAPH RECORD R1646 MAX	MIN	AVE	2A	REDUCED DATA AVE	2A	UNITS	CYC REV.
#1 - Drag Link	6						50	lb	1
#2 - Drag Link	7						84	lb	1
#3 - Drag Link	8								
#1 - Inbd. Flap	13								
#2 - Inbd. Flap	14						600	in-lb	1
#3 - Inbd. Flap	15						500	in-lb	1
#1 - Pitch Link	16						16	lb	1
#2 - Pitch Link	17						20	lb	1
#3 - Pitch Link	18								
#1 - Mid Chord	20								
#1 - Mid Flap	22								
#1 - Mid Torsion	24						30	in-lb	
#1 - Outbd. Flap	26								
Model Attitude	27					-17.2		deg	
Collective Pitch	29								
#1 - Cyclic Pitch	10								
#2 - Cyclic Pitch	11						1.5	deg	1
#3 - Cyclic Pitch	12						1.3	deg	1
Gyro Roll Pos.	19								
Gyro Pitch Pos.	21								
Thrust	33					135		lb	
Drag	31								
Roll Moment	23								
Pitch Moment	25								
Lat. Vibration	28						.069	fps	
Long. Vibration	30						.046	fps	
Vert. Vibration	32						.034	fps	

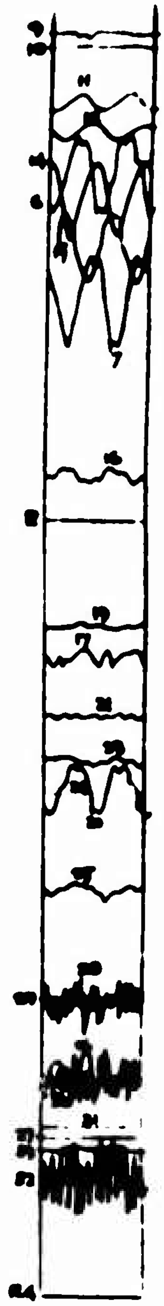


TABLE 17.8 CONFIGURATION [illegible]

n = 1.41 V_{M} = 50 MPH ITEM	#2471 OSCILLOGRAPH RECORD					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNIT	CYC REV.
#1 - Drag Link	6						106	lb	1
#2 - Drag Link	7						162	lb	1
#3 - Drag Link	8								
#1 - Inbd. Flap	13								
#2 - Inbd. Flap	14						455	in-lb	1
#3 - Inbd. Flap	15						460	in-lb	1
#1 - Pitch Link	16						32	lb	1
#2 - Pitch Link	17						37	lb	1
#3 - Pitch Link	18								
#1 - Mid Chord	20								
#1 - Mid Flap	22								
#1 - Mid Torsion	24						45		
#1 - Outbd. Flap	26								
Model Attitude	27					7.3		deg	
Collective Pitch	29								
#1 - Cyclic Pitch	10						5	deg	1
#2 - Cyclic Pitch	11						6	deg	1
#3 - Cyclic Pitch	12						6	deg	1
Gyro Roll Pos.	19								
Gyro Pitch Pos.	21								
Thrust	33					442		lb	
Drag	31								
Roll Moment	23								
Pitch Moment	25								
Lat. Vibration	28						.060	fps	
Long. Vibration	30						.033	fps	
Vert. Vibration	32						.026	fps	

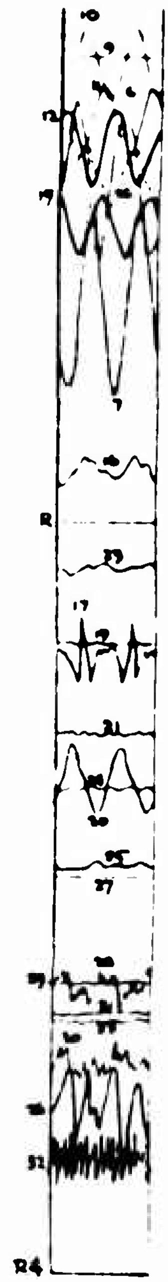


TABLE 17.9 CONFIGURATION O

μ = .95 V_H = 106 MPH ITEM	#2474 OSCILLOGRAPH RECORD					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link	6						68	lb	1
#2 - Drag Link	7						127	lb	1
#3 - Drag Link	8								
#1 - Inbd. Flap	13								
#2 - Inbd. Flap	14						788	in-lb	1
#3 - Inbd. Flap	15						270	in-lb	1
#1 - Pitch Link	16						50	lb	1&3
#2 - Pitch Link	17						41	lb	1&3
#3 - Pitch Link	18								
#1 - Mid Chord	20								
#1 - Mid Flap	22								
#1 - Mid Torsion	24						60	in-lb	
#1 - Outbd. Flap	26								
Model Attitude	27					-6.86		deg	
Collective Pitch	29							deg	
#1 - Cyclic Pitch	10						7	deg	1
#2 - Cyclic Pitch	11						8	deg	1
#3 - Cyclic Pitch	12						8	deg	1
Gyro Roll Pos.	19								
Gyro Pitch Pos.	21								
Thrust	33					300		lb	
Drag	31								
Roll Moment	23								
Pitch Moment	25								
Lat. Vibration	28						.074	fps	
Long. Vibration	30						.031	fps	
Vert. Vibration	32						.041	fps	

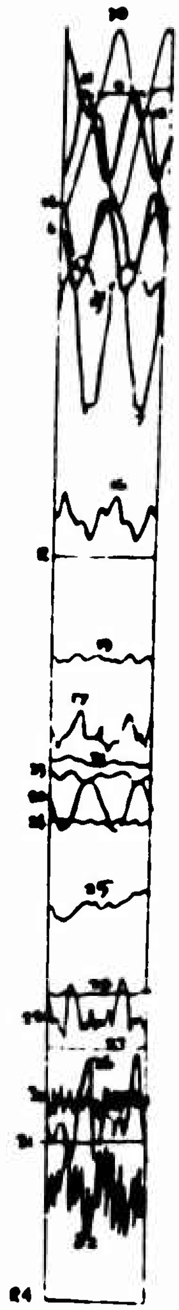


TABLE 17.10 CONFIGURATION G

n = .89 V_M = 106 MPH ITEM	#24d1 OSCILLOGRAPH RECORD					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link	6						58	lb	1
#2 - Drag Link	7						96	lb	1
#3 - Drag Link	8								
#1 - Inbd. Flap	13								
#2 - Inbd. Flap	14						400	in-lb	1
#3 - Inbd. Flap	15						190	in-lb	1
#1 - Pitch Link	16						45	lb	1&3
#2 - Pitch Link	17								
#3 - Pitch Link	18								
#1 - Mid Chord	20								
#1 - Mid Flap	22								
#1 - Mid Torsion	24						120	lb	5
#1 - Outbd. Flap	26								
Model Attitude	27					-6.86		deg	
Collective Pitch	29								
#1 - Cyclic Pitch	10						6	deg	1
#2 - Cyclic Pitch	11						7	deg	1
#3 - Cyclic Pitch	12						7	deg	1
Gyro Roll Pos.	19								
Gyro Pitch Pos.	21								
Thrust	33					281		lb	
Drag	31								
Roll Moment	23								
Pitch Moment	25								
Lat. Vibration	28						.058	fps	2
Long. Vibration	30						.019	fps	
Vert. Vibration	32						.043	fps	3

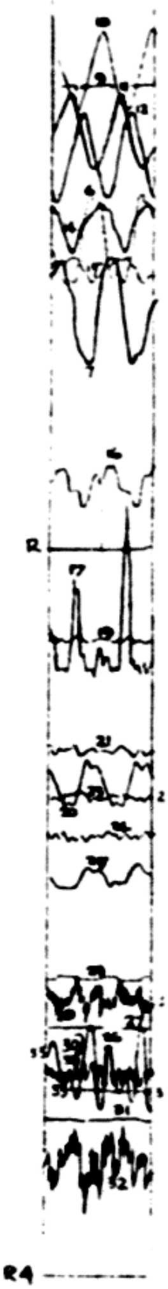


TABLE 17.11 CONFIGURATION 0

μ = .4 V_H = 106 MPH ITEM	RUN OSCILLOGRAPH RECORD					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
φ1 - Drag Link	6						32	lb	1
φ2 - Drag Link	7						44	lb	1
φ3 - Drag Link	8								
φ1 - Inbd. Flap	13								
φ2 - Inbd. Flap	14						777	in-lb	1
φ3 - Inbd. Flap	15						450	in-lb	1
φ1 - Pitch Link	16						34	lb	1&3
φ2 - Pitch Link	17						47	lb	1&3
φ3 - Pitch Link	18								
φ1 - Mid Chord	20								
φ1 - Mid Flap	22								
φ1 - Mid Torsion	24						60	in-lb	5
φ1 - Outbd. Flap	26								
Model Attitude	27					-13.1		deg	
Collective Pitch	29								
φ1 - Cyclic Pitch	30						3	deg	1
φ2 - Cyclic Pitch	31						4	deg	1
φ3 - Cyclic Pitch	32						4	deg	1
Gyro Roll Pos.	19								
Gyro Pitch Pos.	21								
Thrust	33					127		lb	
Drag	31								
Roll Moment	23								
Pitch Moment	25								
Lat. Vibration	28						.060	fps	
Long. Vibration	30						.040	fps	
Vert. Vibration	32						.041	fps	

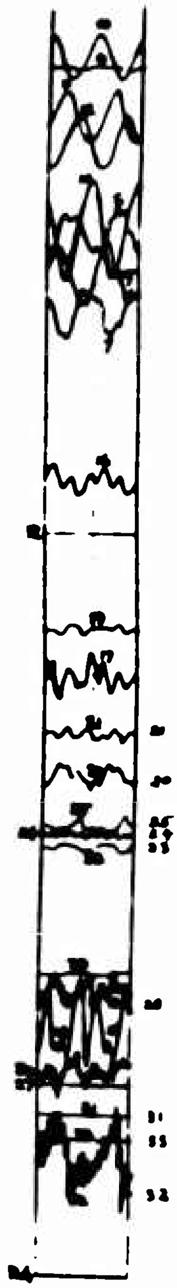


TABLE 17.12   CONFIGURATION G

n = 1.45 V_M = 106 MPH ITEM	TR. No.	#2487 OSCILLOGRAPH RECORD MAX	MIN	AVE	2A	REDUCED DATA AVE	2A	UNITS	CYC REV.
#1 - Drag Link #2 - Drag Link #3 - Drag Link	6 7 8						72 135	lb lb	1 1
#1 - Inbd. Flap #2 - Inbd. Flap #3 - Inbd. Flap	13 14 15						 518 230	 in-lb in-lb	 1 1
#1 - Pitch Link #2 - Pitch Link #3 - Pitch Link	16 17 18						45	lb	1
#1 - Mid Chord #1 - Mid Flap #1 - Mid Torsion #1 - Outbd. Flap	20 22 24 26						 105	 in-lb	
Model Attitude Collective Pitch #1 - Cyclic Pitch #2 - Cyclic Pitch #3 - Cyclic Pitch	27 29 10 11 12					-1.4	 9 9 9	deg deg deg deg	 1 1 1
Gyro Roll Pos. Gyro Pitch Pos.	19 21								
Thrust Drag Roll Moment Pitch Moment	33 31 23 25					453		lb	
Lat. Vibration Long. Vibration Vert. Vibration	28 30 32						.101 .041 .071	fps fps fps	

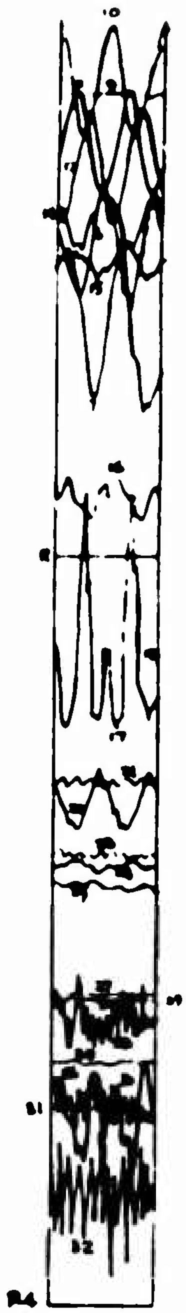


TABLE 17.13 CONFIGURATION O

n = 1.05 V_H = 106 MPH ITEM	TR. No.	OSCILLOGRAPH RECORD MAX	MIN	AVE	2A	REDUCED DATA AVE	2A	UNITS	CYC REV.
#1 - Drag Link #2 - Drag Link #3 - Drag Link	6 7 8						118 191	lb lb	1 1
#1 - Inbd. Flap #2 - Inbd. Flap #3 - Inbd. Flap	13 14 15						130 190	in-lb in-lb	1 1
#1 - Pitch Link #2 - Pitch Link #3 - Pitch Link	16 17 18						64	lb	1
#1 - Mid Chord #1 - Mid Flap #1 - Mid Torsion #1 - Outbd. Flap	20 22 24 26						90	in-lb	1
Model Attitude Collective Pitch #1 - Cyclic Pitch #2 - Cyclic Pitch #3 - Cyclic Pitch	27 29 10 11 12					3.92	9 10 10	deg deg deg deg	1 1 1
Gyro Roll Pos. Gyro Pitch Pos.	19 20								
Thrust Drag Roll Moment Pitch Moment	33 31 23 25					580		lb	
Lat. Vibration Long. Vibration Vert. Vibration	28 30 32						.065 .053 .032	fps fps fps	

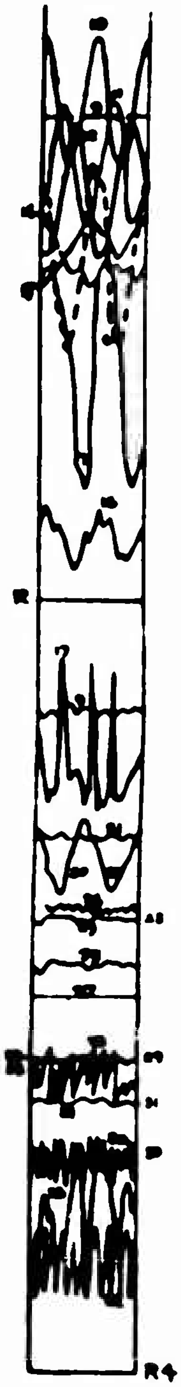


TABLE 13.1 CONFIGURATION H

n = .79 V_M = 50 MPH (Ω = 850 RPM) ITEM	#2520 OSCILLOGRAPH RECORD					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link	6						139	lb	1
#2 - Drag Link	7						183	lb	1
#3 - Drag Link	8								
#1 - Inbd. Flap	13						338	in-lb	1
#2 - Inbd. Flap	14						270	in-lb	1
#3 - Inbd. Flap	15								
#1 - Pitch Link	16						31	lb	1
#2 - Pitch Link	17								
#3 - Pitch Link	18								
#1 - Mid Chord	20								
#1 - Mid Flap	22								
#1 - Mid Torsion	24						105	in-lb	
#1 - Outbd. Flap	26								
Model Attitude	27					.42		deg	
Collective Pitch	29								
#1 - Cyclic Pitch	10								
#2 - Cyclic Pitch	11								
#3 - Cyclic Pitch	12								
Gyro Roll Pos.	19								
Gyro Pitch Pos.	21								
Thrust	33					249		lb	
Drag	31								
Roll Moment	23								
Pitch Moment	25								
Lat. Vibration	28						.12	fps	
Long. Vibration	30						.065	fps	
Vert. Vibration	32						.041	fps	

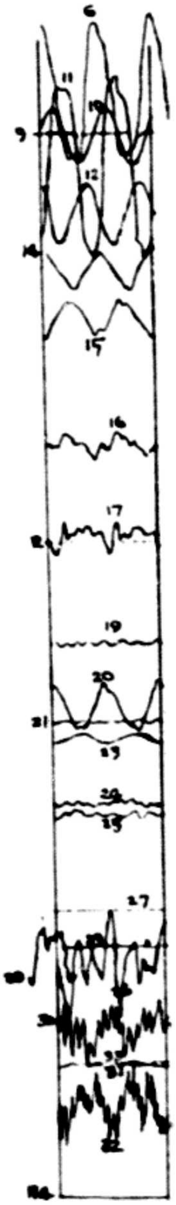


TABLE 18.2 CONFIGURATION H

n = .53 V_H = 50 MPH ITEM	TR. No.	#2523 OSCILLOGRAPH RECORD MAX	MIN	AVE	2A	REDUCED DATA AVE	2A	UNITS	CYC REV.
#1 - Drag Link	6						55	lb	1
#2 - Drag Link	7						104	lb	1
#3 - Drag Link	8								
#1 - Inbd. Flap	13								
#2 - Inbd. Flap	14						300	in-lb	1
#3 - Inbd. Flap	15						230	in-lb	1
#1 - Pitch Link	16						35	lb	3&1
#2 - Pitch Link	17						51	lb	3&1
#3 - Pitch Link	18								
#1 - Mid Chord	20								
#1 - Mid Flap	22								
#1 - Mid Torsion	24						60	in-lb	
#1 - Outbd. Flap	26								
Model Attitude	27					-8.0		deg	
Collective Pitch	29								
#1 - Cyclic Pitch	10								
#2 - Cyclic Pitch	11								
#3 - Cyclic Pitch	12								
Gyro Roll Pos.	19								
Gyro Pitch Pos.	21								
Thrust	33					166		lb	
Drag	31								
Roll Moment	23								
Pitch Moment	25								
Lat. Vibration	28						.096	fps	
Long. Vibration	30						.065	fps	2
Vert. Vibration	32						.048	fps	3

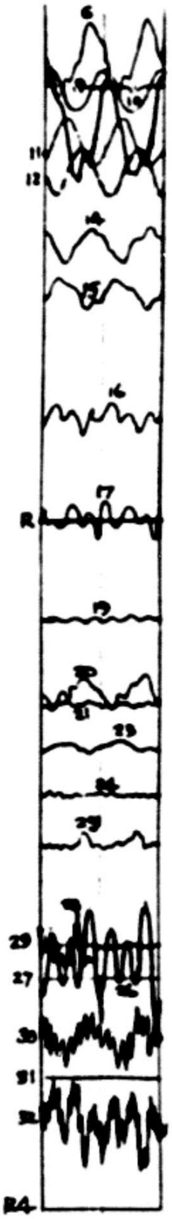


TABLE 18.3 CONFIGURATION H

n = 1.05 V_H = 50 MPH (Ω = 850 RPM) ITEM	#2526 OSCILLOGRAPH RECORD					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link	6						136	lb	1
#2 - Drag Link	7						227	lb	1
#3 - Drag Link	8								
#1 - Inbd. Flap	13								
#2 - Inbd. Flap	14						111	in-lb	1
#3 - Inbd. Flap	15						130	in-lb	1
#1 - Pitch Link	16						38	lb	1
#2 - Pitch Link	17								
#3 - Pitch Link	18								
#1 - Mid Chord	20								
#1 - Mid Flap	22								
#1 - Mid Torsion	24						105	in-lb	
#1 - Outbd. Flap	26								
Model Attitude	27					6.3		deg	
Collective Pitch	29								
#1 - Cyclic Pitch	10								
#2 - Cyclic Pitch	11								
#3 - Cyclic Pitch	12								
Gyro Roll Pos.	19								
Gyro Pitch Pos.	21								
Thrust	33					331		lb	
Drag	31								
Roll Moment	23								
Pitch Moment	25								
Lat. Vibration	28						.116	fps	2
Long. Vibration	30						.063	fps	2
Vert. Vibration	32						.041	fps	3

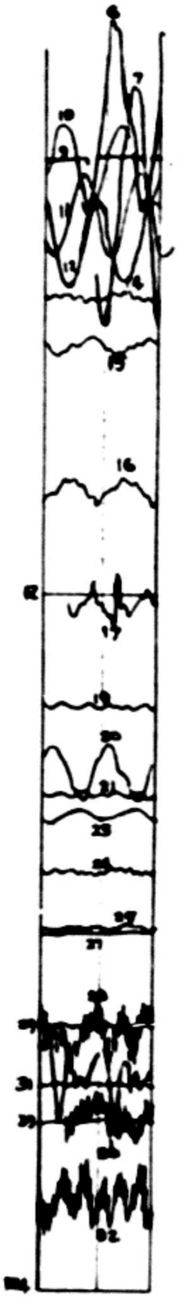


TABLE 18.4 CONFIGURATION H

n = .28 V_H = 50 MPH (Ω = 630 RPM) ITEM	#2529 OSCILLOGRAPH RECORD					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
ϕ1 - Drag Link	6						12	lb	1
ϕ2 - Drag Link	7						28	lb	1
ϕ3 - Drag Link	8								
ϕ1 - Inbd. Flap	13								
ϕ2 - Inbd. Flap	14						366	in-lb	1
ϕ3 - Inbd. Flap	15						260	in-lb	1
ϕ1 - Pitch Link	16						13	lb	
ϕ2 - Pitch Link	17								
ϕ3 - Pitch Link	18								
ϕ1 - Mid Chord	20								
ϕ1 - Mid Flap	22								
ϕ1 - Mid Torsion	24								
ϕ1 - Outbd. Flap	26								
Model Attitude	27					0.56		deg	
Collective Pitch	29								
ϕ1 - Cyclic Pitch	10								
ϕ2 - Cyclic Pitch	11								
ϕ3 - Cyclic Pitch	12								
Gyro Roll Pos.	17								
Gyro Pitch Pos.	21								
Thrust	33					85		lb	
Drag	31								
Roll Moment	23								
Pitch Moment	25								
Lat. Vibration	28						.106	fps	
Long. Vibration	30						.035	fps	
Vert. Vibration	32						.020	fps	

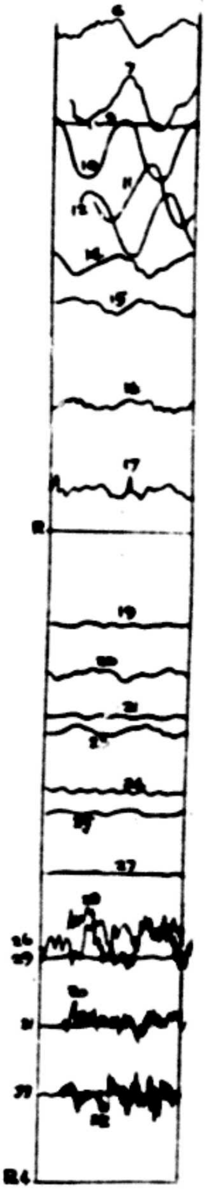


TABLE 18.5 CONFIGURATION II

n $ 0 V_H = 50 MPH (Ω = 650 RPM) ITEM	TR. No.	#2532 OSCILLOGRAPH RECORD MAX	MIN	AVE	2A	REDUCED DATA AVE	2A	UNITS	CYC REV.
#1 - Drag Link	6						14	lb	1
#2 - Drag Link	7						17	lb	1
#3 - Drag Link	8								
#1 - Inbd. Flap	13								
#2 - Inbd. Flap	14						577	in-lb	1
#3 - Inbd. Flap	15						380	in-lb	1
#1 - Pitch Link	16						7	lb	
#2 - Pitch Link	17						11	lb	
#3 - Pitch Link	18								
#1 - Mid Chord	20								
#1 - Mid Flap	22						30	in-lb	
#1 - Mid Torsion	24								
#1 - Outbd. Flap	26								
Model Attitude	27					-10.2		deg	
Collective Pitch	29								
#1 - Cyclic Pitch	10								
#2 - Cyclic Pitch	11								
#3 - Cyclic Pitch	12								
Gyro Roll Pos.	19								
Gyro Pitch Pos.	21								
Thrust	33					0		lb	
Drag	31								
Roll Moment	23								
Pitch Moment	25								
Lat. Vibration	28						.079	fps	
Long. Vibration	30						.029	fps	1
Vert. Vibration	32						.014	fps	3

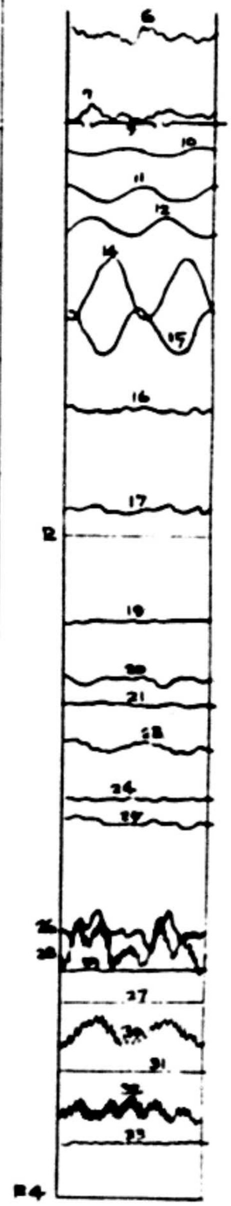


TABLE 18.6 CONFIGURATION H

$n = .36$ $V_M = 50$ MPH ($\Omega = 650$ RPM) ITEM	TR. No.	#2535 OSCILLOGRAPH RECORD MAX	MIN	AVE	2A	REDUCED DATA AVE	2A	UNITS	CYC REV.
#1 - Drag Link	6						21	lb	1
#2 - Drag Link	7						55	lb	1
#3 - Drag Link	8								
#1 - Inbd. Flap	13								
#2 - Inbd. Flap	14						222	in-lb	1
#3 - Inbd. Flap	15						150	in-lb	1
#1 - Pitch Link	16						15	lb	1
#2 - Pitch Link	17								
#3 - Pitch Link	18								
#1 - Mid Chord	20								
#1 - Mid Flap	22								
#1 - Mid Torsion	24						60	in-lb	
#1 - Outbd. Flap	26								
Model Attitude	27					3.4		deg	
Collective Pitch	29								
#1 - Cyclic Pitch	10								
#2 - Cyclic Pitch	11								
#3 - Cyclic Pitch	12								
Gyro Roll Pos.	19								
Gyro Pitch Pos.	21								
Thrust	33					112		lb	
Drag	31								
Roll Moment	23								
Pitch Moment	25								
Lat. Vibration	28						.096	fps	
Long. Vibration	30						.029	fps	
Vert. Vibration	32						.026	fps	

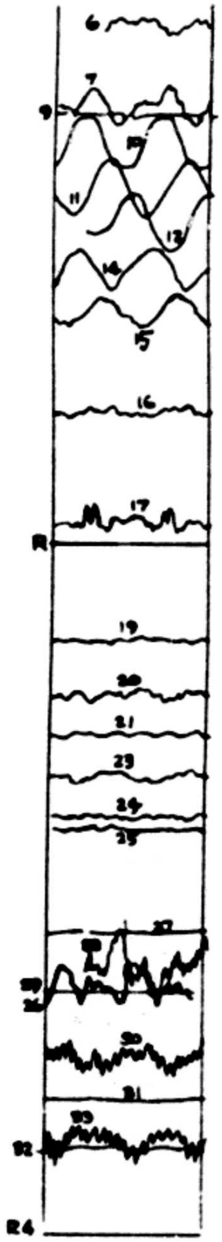


TABLE 1[illegible].7 CONFIGURATION H

n = .56 V_M = 106 MPH (Ω = 915 RPM) ITEM	TR. No.	#2538 OSCILLOGRAPH RECORD				REDUCED DATA			
		MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link #2 - Drag Link #3 - Drag Link	6 7 8						49 104	lb lb	1 1
#1 - Inbd. Flap #2 - Inbd. Flap #3 - Inbd. Flap	13 14 15						 389 230	 in-lb in-lb	 1 1
#1 - Pitch Link #2 - Pitch Link #3 - Pitch Link	16 17 18						29	lb	1&3
#1 - Mid Chord #1 - Mid Flap #1 - Mid Torsion #1 - Outbd. Flap	20 22 24 26						 105	 in-lb	
Model Attitude Collective Pitch #1 - Cyclic Pitch #2 - Cyclic Pitch #3 - Cyclic Pitch	27 29 10 11 12					0		deg	
Gyro Roll Pos. Gyro Pitch Pos.	19 21								
Thrust Drag Roll Moment Pitch Moment	33 31 23 25					177		lb	
Lat. Vibration Long. Vibration Vert. Vibration	28 30 32						.075 .036 .033	fps fps fps	2 1 1

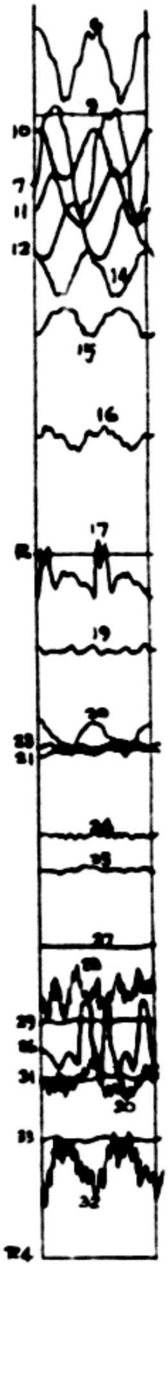


TABLE 18.8 CONFIGURATION H

μ = .26 V_H = 106 MPH (Ω = 930 RPM) ITEM	Tr. No.	#2541 OSCILLOGRAPH RECORD MAX	MIN	AVE	2A	REDUCED DATA AVE	2A	UNITS	CYC REV.
#1 - Drag Link	6						34	lb	1
#2 - Drag Link	7						72	lb	1
#3 - Drag Link	8								
#1 - Inbd. Flap	13								
#2 - Inbd. Flap	14						300	in-lb	1
#3 - Inbd. Flap	15						170	in-lb	1
#1 - Pitch Link	16						26	lb	1
#2 - Pitch Link	17								
#3 - Pitch Link	18								
#1 - Mid Chord	20								
#1 - Mid Flap	[illegible]								
#1 - Mid Torsion	44						90	in-lb	
#1 - Outbd. Flap	26								
Model Attitude	27					-5.6		deg	
Collective Pitch	29								
#1 - Cyclic Pitch	10								
#2 - Cyclic Pitch	11								
#3 - Cyclic Pitch	12								
Gyro Roll Pos.	19								
Gyro Pitch Pos.	21								
Thrust	33					81		lb	
Drag	31								
Roll Moment	23								
Pitch Moment	25								
Lat. Vibration	28						.074	fps	3
Long. Vibration	30						.038	fps	
Vert. Vibration	32						.026	fps	

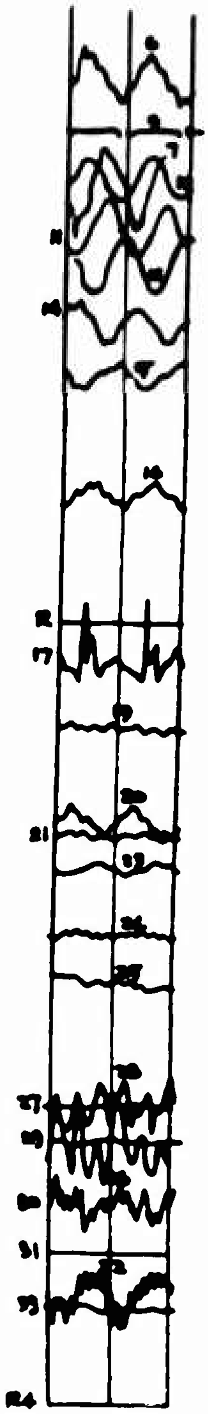


TABLE 18.9 CONFIGURATION H

μ = .91 (Ω = 920 RPM) V_H = 106 MPH ITEM	TR. No.	#9544 OSCILLOGRAPH RECORD MAX	MIN	AVE	2A	REDUCED DATA AVE	2A	UNITS	CYC REV.
φ1 - Drag Link	6						81	lb	1
φ2 - Drag Link	7						133	lb	1
φ3 - Drag Link	8								
φ1 - Inbd. Flap	13								
φ2 - Inbd. Flap	14						440	in-lb	1
φ3 - Inbd. Flap	15						290	in-lb	1
φ1 - Pitch Link	16						44	lb	1
φ2 - Pitch Link	17								
φ3 - Pitch Link	18								
φ1 - Mid Chord	20								
φ1 - Mid Flap	22								
φ1 - Mid Torsion	24						105	in-lb	
φ1 - Outbd. Flap	26								
Model Attitude	27					4.5		deg	
Collective Pitch	29								
φ1 - Cyclic Pitch	10								
φ2 - Cyclic Pitch	11								
φ3 - Cyclic Pitch	12								
Gyro Roll Pos.	19								
Gyro Pitch Pos.	21								
Thrust	33					285		lb	
Drag	31								
Roll Moment	23								
Pitch Moment	25								
Lat. Vibration	28						.111	fps	
Long. Vibration	30						.048	fps	
Vert. Vibration	32						.038	fps	3

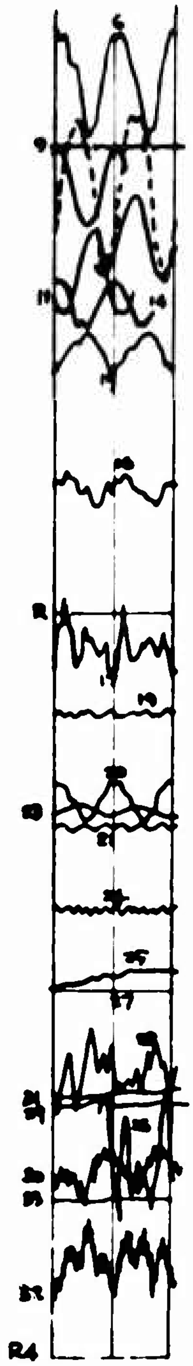


TABLE 18.10 CONFIGURATION H

μ = .09 V_M = 106 MPH (Ω = 640 RPM) ITEM	#2547 OSCILLOGRAPH RECORD					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link #2 - Drag Link #3 - Drag Link	6 7 8						21 36	lb lb	1 1
#1 - Inbd. Flap #2 - Inbd. Flap #3 - Inbd. Flap	13 14 15						 610 270	 in-lb in-lb	 1 1
#1 - Pitch Link #2 - Pitch Link #3 - Pitch Link	16 17 18						10	lb	1
#1 - Mid Chord #1 - Mid Flap #1 - Mid Torsion #1 - Outbd. Flap	20 22 24 26						 60	 in-lb	
Model Attitude Collective Pitch #1 - Cyclic Pitch #2 - Cyclic Pitch #3 - Cyclic Pitch	27 29 10 11 12					0		deg	
Gyro Roll Pos. Gyro Pitch Pos.	19 21								
Thrust Drag Roll Moment Pitch Moment	33 31 23 25					35		lb	
Lat. Vibration Long. Vibration Vert. Vibration	28 30 32						.087 .033 .031	fps fps fps	1&2 1&2 1

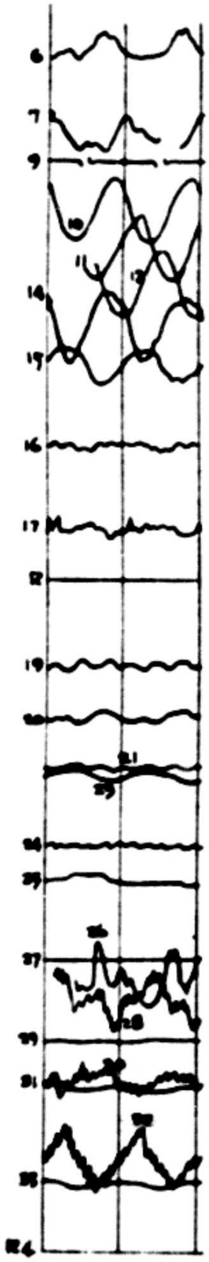


TABLE 18.11 CONFIGURATION H

n = 0 (Ω = 640 RPM) V_H = 105 MPH ITEM	#2550 OSCILLOGRAPH RECORD					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link #2 - Drag Link #3 - Drag Link	6 7 8						18 28	lb lb	1 1
#1 - Inbd. Flap #2 - Inbd. Flap #3 - Inbd. Flap	13 14 15						588 240	in-lb in-lb	1 1
#1 - Pitch Link #2 - Pitch Link #3 - Pitch Link	16 17 18						9	lb	
#1 - Mid Chord #1 - Mid Flap #1 - Mid Torsion #1 - Outbd. Flap	20 22 24 26								
Model Attitude Collective Pitch #1 - Cyclic Pitch #2 - Cyclic Pitch #3 - Cyclic Pitch	27 29 10 11 12					- 3.5		deg	
Gyro Roll Pos. Gyro Pitch Pos.	19 21								
Thrust Drag Roll Moment Pitch Moment	33 31 23 25					0			
Lat. Vibration Long. Vibration Vert. Vibration	28 30 32						.065 .024 .029	fps fps fps	1 1 1

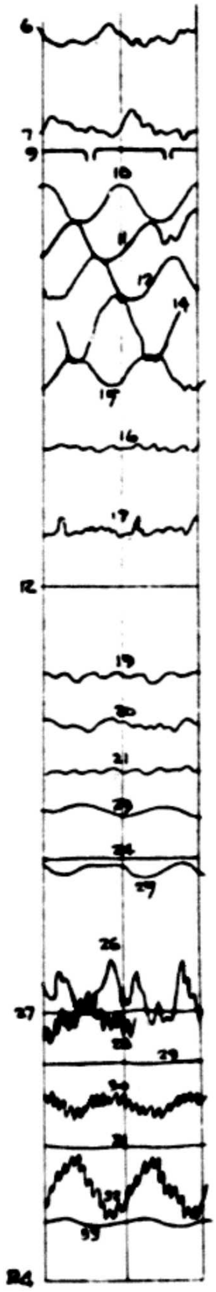
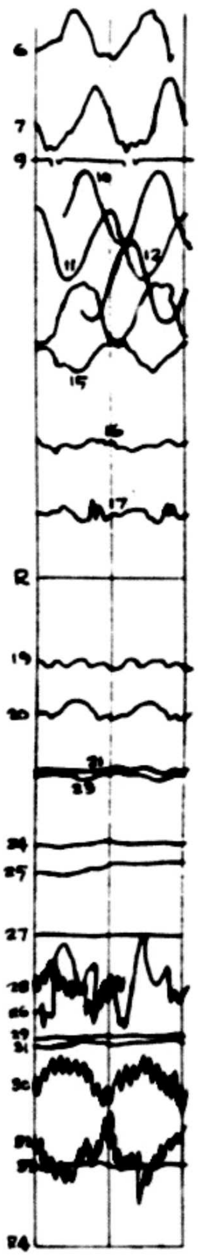


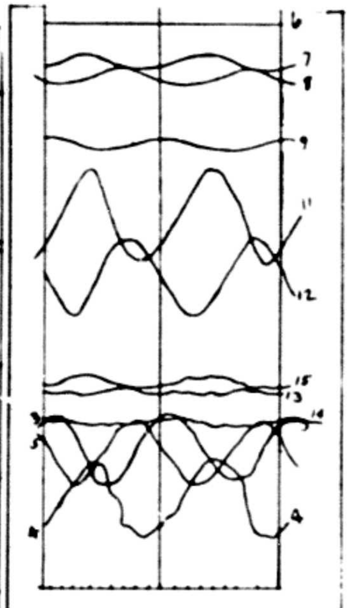
TABLE 18.12 CONFIGURATION H

n = .26 (Ω = 640 RPM) V_M = 106 MPH	#2556 OSCILLOGRAPH RECORD					REDUCED DATA			
ITEM	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link	6						37	lb	1
#2 - Drag Link	7						74	lb	1
#3 - Drag Link	8								
#1 - Inbd. Flap	13								
#2 - Inbd. Flap	14						500	in-lb	1
#3 - Inbd. Flap	15						280	in-lb	1
#1 - Pitch Link	16						13	lb	1&3
#2 - Pitch Link	17								
#3 - Pitch Link	18								
#1 - Mid Chord	20								
#1 - Mid Flap	22								
#1 - Mid Torsion	24						45	in-lb	
#1 - Outbd. Flap	26								
Model Attitude	27					2.52		deg	
Collective Pitch	29								
#1 - Cyclic Pitch	10								
#2 - Cyclic Pitch	11								
#3 - Cyclic Pitch	12								
Gyro Roll Pos.	19								
Gyro Pitch Pos.	21								
Thrust	33					81		lb	
Drag	31								
Roll Moment	23								
Pitch Moment	25								
Lat. Vibration	28						.128	fps	
Long. Vibration	30						.050	fps	
Vert. Vibration	32						.040	fps	

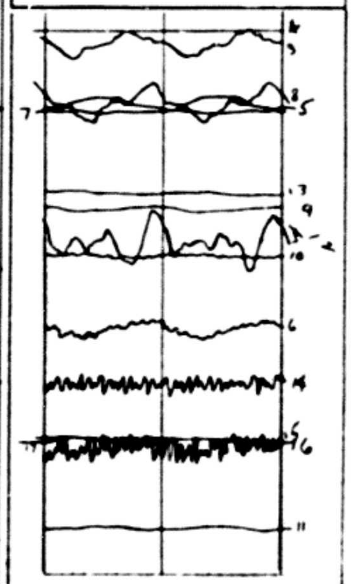


TABLES 19.1a and 19.1b ~ CONFIGURATION J

n = .47 ITEM	#17628 & 07628 OSCILLOGRAPH RECORD					REDUCED DATA		
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS
ø1 - Drag Link	1-3	1.43	.86	1.15	.57	-463.4	58.3	lb
ø2 - Drag Link	1-4	1.06	.42	.74	.64	-468.8	66.8	
ø3 - Drag Link	1-5	1.36	.85	1.11	.51	-428.8	53.9	
ø1 - Inbd. Flap	1-10							in-lb
ø2 - Inbd. Flap	1-11	3.45	2.69	3.07	.76	244.0	806.4	
ø3 - Inbd. Flap	1-12	2.89	2.25	2.57	.64	- 10.4	664.3	
ø1 - Pitch Link	1-13	1.64	1.59	1.62	.05	-312.8	8.64	lb
ø2 - Pitch Link	1-14	1.40	1.33	1.37	.07	- 50.9	11.87	
ø3 - Pitch Link	1-15	1.75	1.65	1.70	.10	- 9.08	18.16	
ø1 - Mid Chord	2-6	2.10	1.95	2.03	.15	-3728.6	309.0	in-lb
ø1 - Mid Flap	2-8	4.07	3.74	3.91	.33	279.5	141.9	
ø1 - Mid Torsion	2-10	2.65	2.63	2.64	.02	- 68.6	34.3	
ø1 - Outbd. Flap	2-12	3.02	2.50	2.76	.52	98.4	86.7	
Model Attitude	2-11	.40	.38	.39	.02	- 13.5		deg
Collective Pitch	2-13	3.16	3.14	3.15	.02	6.61		
ø1 - Cyclic Pitch	1-7	4.40	4.28	4.34	.12	5.29		
ø2 - Cyclic Pitch	1-8	4.29	4.15	4.22	.14	7.36		
ø3 - Cyclic Pitch	1-9	3.71	3.61	3.66	.10	5.52		
Gyro Roll Pos.	2-3	4.50	4.27	4.39	.23	- 1.73		deg
Gyro Pitch Pos.	2-5	3.95	3.85	3.90	.10	- 1.10		
Thrust	2-17	1.12	1.09	1.11	.03	146.5		lb
Drag	2-15	1.12	1.12	1.12	0	- .51		
Roll Moment	2-7	3.83	3.81	3.82	.02			
Pitch Moment	2-9	3.04	3.00	3.02	.04			
Lat. Vibration	2-14	1.65	1.47	1.56	.18		.486	ft/sec^2
Long. Vibration	2-16	1.18	.90	1.04	.28		.70	
Vert. Vibration	1-16							G



OSCILLOGRAPH # 17628



OSCILLOGRAPH # 07628

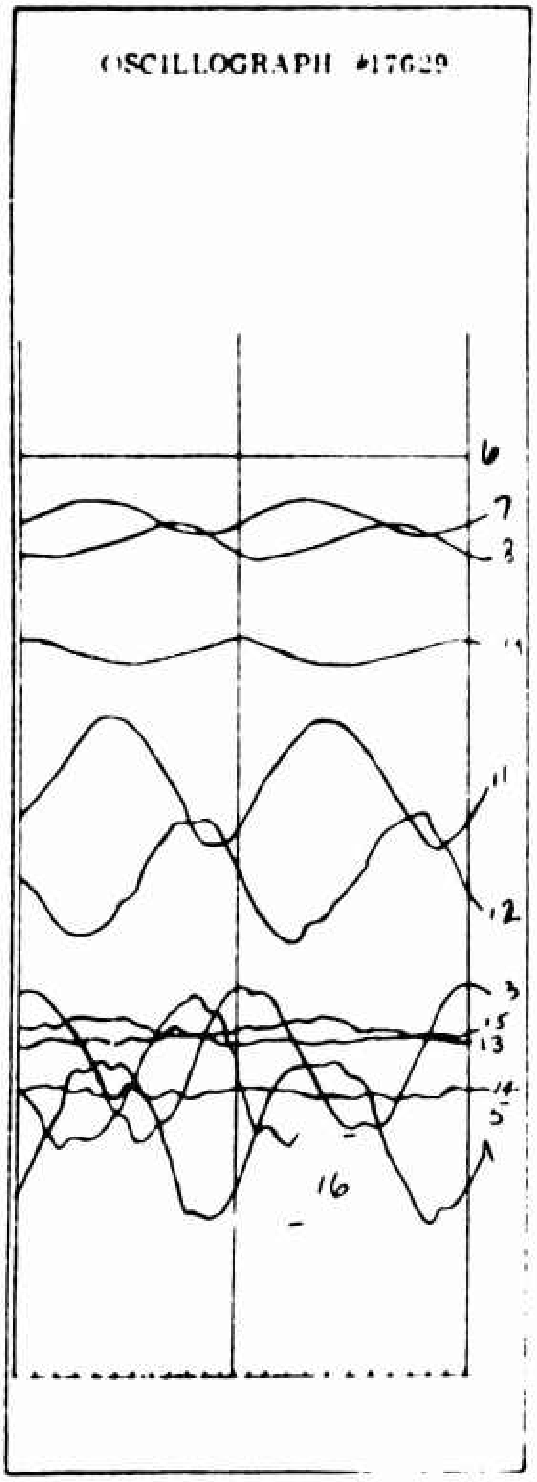
TABLE 19.2a CONFIGURATION J

n = .25 (Ω = 500 RPM)	#17629 407629 OSCILLOGRAPH RECORD					REDUCED DATA			
ITEM	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link	1-3	1.96	1.18	1.57	.78	-420.0	80.5	lb	
#2 - Drag Link	1-4	1.58	.76	1.17	.82	-434.3	85.6	lb	
#3 - Drag Link	1-5	1.94	1.16	1.55	.78	-382.3	32.4	lb	
#1 - Inbd. Flap	1-10								
#2 - Inbd. Flap	1-11	3.33	2.67	3.00	.66	169.8	700.3	in-lb	
#3 - Inbd. Flap	1-12	2.73	2.20	2.47	.53	-114.2	550.1	in-lb	
#1 - Pitch Link	1-13	1.71	1.67	1.69	.04	- 67.4	6.91	lb	
#2 - Pitch Link	1-14	1.47	1.40	1.44	.07	- 39.0	11.87	lb	
#3 - Pitch Link	1-15	1.81	1.72	1.77	.09	3.63	163.5	lb	
#1 - Mid Chord	2-6	2.44	2.25	2.35	.19	-3069.4	391.4	in-lb	
#1 - Mid Flap	2-8	4.01	3.66	3.84	.35	249.4	150.5	in-lb	
#1 - Mid Torsion	2-10	2.67	2.65	2.66	.02	- 34.3	34.3	in-lb	
#1 - Outbd. Flap	2-12	3.06	2.61	2.84	.45	111.7	75.0	in-lb	
Model Attitude	2-11	.38	.38	.38	0	- 13.5		deg	
Collective Pitch	2-13	3.17	3.14	3.16	.03	6.66		deg	
#1 - Cyclic Pitch	1-7	4.43	4.27	4.35	.16	5.52		deg	
#2 - Cyclic Pitch	1-8	4.33	4.14	4.24	.19	7.82		deg	
#3 - Cyclic Pitch	1-9	3.72	3.61	3.67	.11	5.75		deg	
Gyro Roll Pos.	2-3	4.64	4.42	4.53	.22	- 1.24		deg	
Gyro Pitch Pos.	2-5	3.93	3.85	3.89	.08	- 1.15		deg	
Thrust	2-17	.89	.87	.38	.02	79.1		lb	
Drag	2-15	1.12	1.12	1.12	0	- .51		lb	
Roll Moment	2-7	3.83	3.81	3.82	.02			lb	
Pitch Moment	2-9	2.98	2.93	2.99	0			lb	
Lat. Vibration	2-14	1.66	1.50	1.59	.16		.432	ft/sec^2	
Long. Vibration	2-16	1.24	.85	1.06	.36		.90	G	
Vert. Vibration	1-16	1.21	.76	.99	.45				

TABLE 19.2b CONFIGURATION J

$n = .25$

(Ω = 500 RPM)



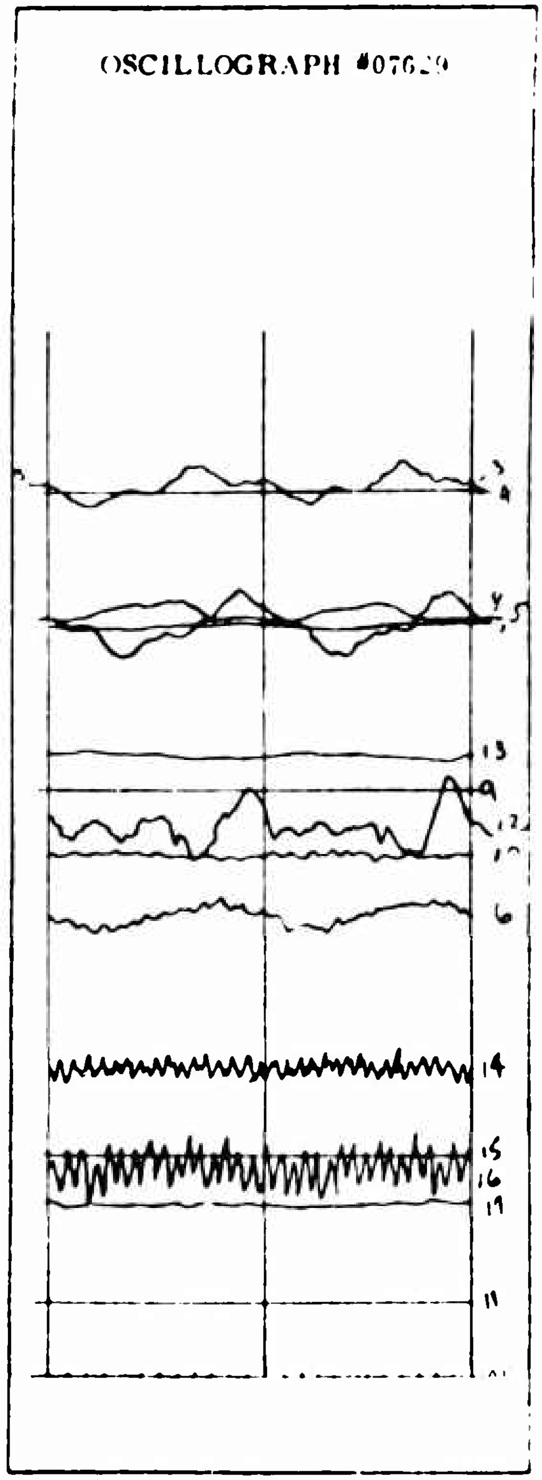


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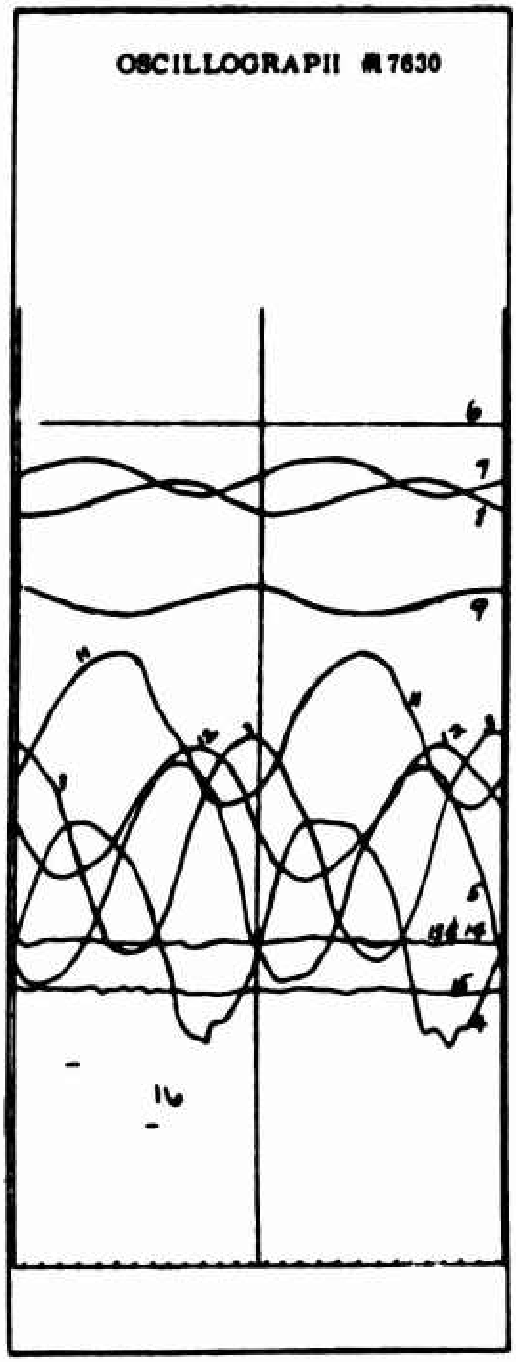
TABLE 19.3a CONFIGURATION J

n = .13 (Ω = 426 RPM) ITEM	#17630 & #07630 OSCILLOGRAPH RECORD					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link	1-3	2.95	1.69	2.32	1.26	- 342.6	130.0	lb	
#2 - Drag Link	1-4	2.46	1.22	1.84	1.24	- 364.4	129.5	lb	
#3 - Drag Link	1-5	2.79	1.56	2.18	1.23	- 315.8	129.9	lb	
#1 - Inbd. Flap	1-10								
#2 - Inbd. Flap	1-11	3.39	2.53	2.96	.86	+ 127.3	912.5	in-lb	
#3 - Inbd. Flap	1-12	2.88	2.16	2.52	.72	- 62.3	747.4	in-lb	
#1 - Pitch Link	1-13	1.80	1.75	1.79	.02	- 50.1	3.46	lb	
#2 - Pitch Link	1-14	1.80	1.78	1.79	.02	+ 20.3	3.39	lb	
#3 - Pitch Link	1-15	1.55	1.51	1.53	.04	- 40.0	7.26	lb	
#1 - Mid Chord	2-6	2.80	2.56	2.68	.24	-2389.6	494.0	in-lb	
#1 - Mid Flap	2-8	3.99	3.51	3.75	.48	+ 210.7	206.4	in-lb	
#1 - Mid Torsion	2-10	2.67	2.65	2.66	.02	- 34.3	34.3	in-lb	
#1 - Outbd. Flap	2-12	3.00	2.48	2.74	.52	+ 95.0	86.7	in-lb	
Model Attitude	2-11	.38	.38	.38	0	- 13.5		deg	
Collective Pitch	2-13	3.17	3.13	3.15	.04	+ 6.61		deg	
#1 - Cyclic Pitch	1-7	4.46	4.27	4.37	.19	+ 5.98		deg	
#2 - Cyclic Pitch	1-8	4.34	4.16	4.25	.18	+ 8.05		deg	
#3 - Cyclic Pitch	1-9	3.75	3.61	3.68	.14	+ 5.98		deg	
Gyro Roll Pos.	2-3	4.78	4.50	4.64	.28	- .86		deg	
Gyro Pitch Pos.	2-5	4.44	3.84	4.14	.60	+ .16		deg	
Thrust	2-17	.75	.75	.75	0	+ 41.0		lb	
Drag	2-15	1.12	1.12	1.12	0	- .51		lb	
Roll Moment	2-7	3.87	3.82	3.85	.05			lb	
Pitch Moment	2-9	3.01	2.99	3.00	.02			lb	
Lat. Vibration	2-14	1.62	1.52	1.57	.10		.27	$\frac{ft/sec^2}{G}$	
Long. Vibration	2-16	1.16	.94	1.05	.22		.55		
Vert. Vibration	1-16	1.11	.78	.95	.33		.825		

TABLE 19.3b CONFIGURATION J

μ = .13

(Ω = 426 RPM)



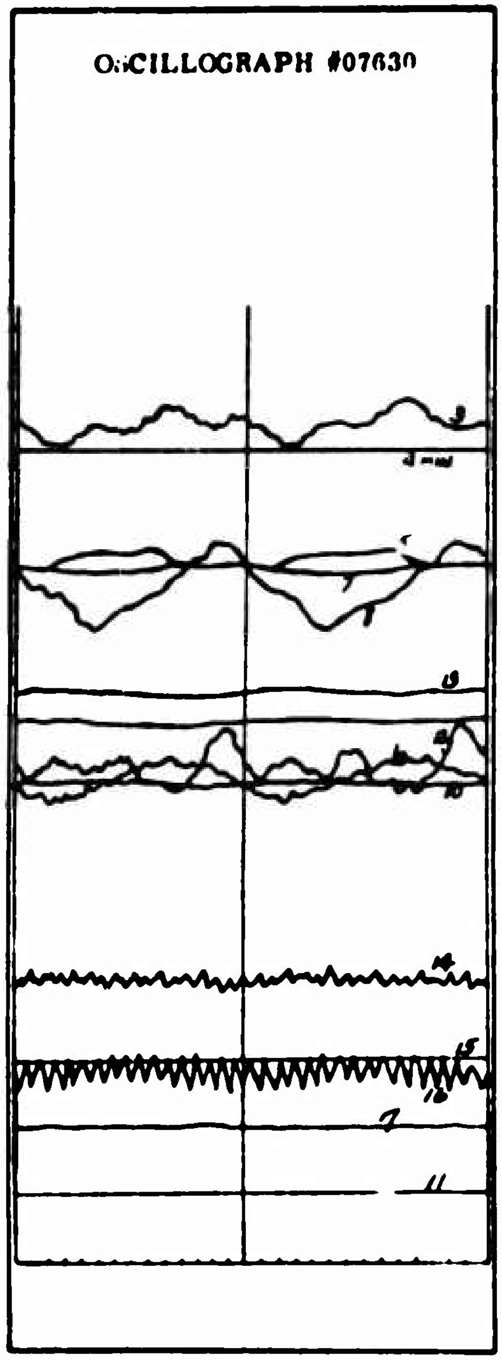


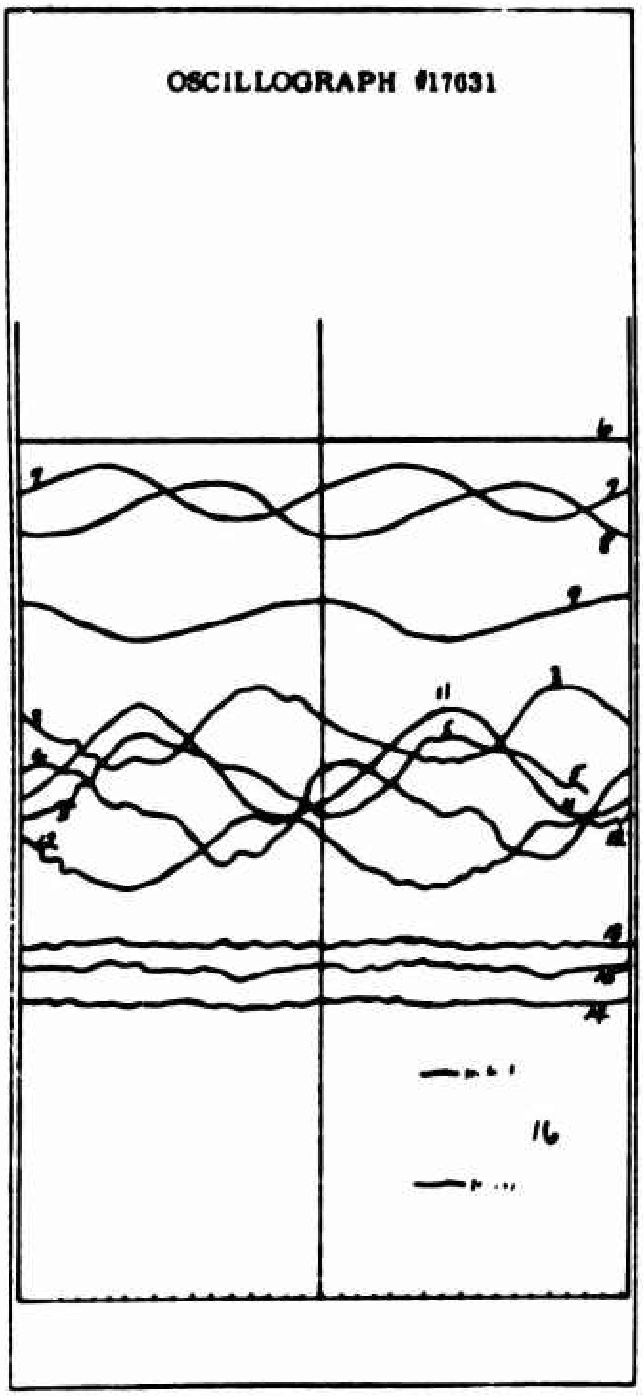
TABLE 19.4a CONFIGURATION J

n = .05 (Ω = 352 RPM) ITEM	#17631 & #17631 OSCILLOGRAPH RECORD TR. No.	MAX	MIN	AVE	2A	REDUCED DATA AVE	2A	UNITS	CYC REV.
#1 - Drag Link	1-3	3.32	2.89	3.11	.43	- 261.1	44.4	lb	
#2 - Drag Link	1-4	2.91	2.37	2.64	.54	- 280.8	56.4	lb	
#3 - Drag Link	1-5	3.06	2.59	2.83	.47	- 247.1	49.6	lb	
#1 - Inbd. Flap	1-10								
#2 - Inbd. Flap	1-11	3.22	2.62	3.92	.60	+1145.9	636.6	in-lb	
#3 - Inbd. Flap	1-12	2.62	2.24	2.43	.38	- 155.7	394.4	in-lb	
#1 - Pitch Link	1-13	1.96	1.91	1.94	.05	- 24.2	8.64	lb	
#2 - Pitch Link	1-14	1.64	1.60	1.62	.04	- 8.48	6.78	lb	
#3 - Pitch Link	1-15	1.83	1.75	1.79	.03	+ 7.26	14.5	lb	
#1 - Mid Chord	2-6	3.10	3.00	3.05	.10	-1627.4	206.0	in-lb	
#1 - Mid Flap	2-8	3.89	3.39	3.64	.50	- 163.4	215.0	in-lb	
#1 - Mid Torsion	2-10	2.69	2.67	2.68	.02	0	34.3	in-lb	
#1 - Outbd. Flap	2-12	3.00	2.52	2.76	.48	+ 98.4	80.0	in-lb	
Model Attitude	2-11	.39	.39	.39	0	- 13.5		deg	
Collective Pitch	2-13	3.18	3.15	3.17	.03	+ 6.71		deg	
#1 - Cyclic Pitch	1-7	4.52	4.23	4.38	.29	+ 6.21		deg	
#2 - Cyclic Pitch	1-8	4.43	4.14	4.29	.29	+ 8.97		deg	
#3 - Cyclic Pitch	1-9	3.80	3.59	3.70	.21	+ 6.44		deg	
Gyro Roll Pos.	2-3	4.93	4.61	4.77	.32	- .41		deg	
Gyro Pitch Pos.	2-5	3.87	3.71	3.79	.16	- 1.68		deg	
Thrust	2-17	.67	.65	.66	.02	+ 14.7		lb	
Drag	2-15	1.12	1.12	1.12	0	- .51		lb	
Roll Moment	2-7	3.87	3.79	3.83	.08			lb	
Pitch Moment	2-9	2.97	2.89	2.93	.08			lb	
Lat. Vibration	2-14	1.65	1.52	1.59	.13		.351	$\frac{ft/sec^2}{G}$	
Long. Vibration	2-16	1.13	.93	1.03			.50		
Vert. Vibration	1-16	1.22	.62	.92	.60		1.50		

TABLE 19.4b CONFIGURATION J

$n = .05$

$(\Omega' = 352 \text{ RPM})$



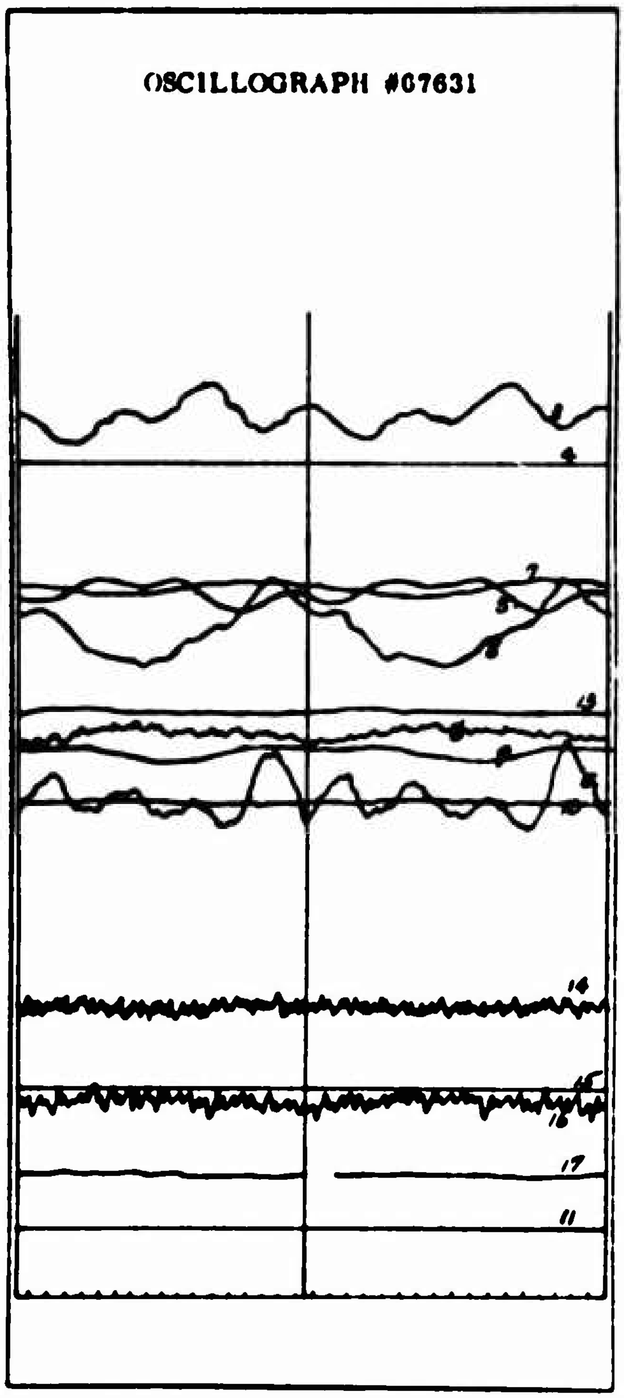


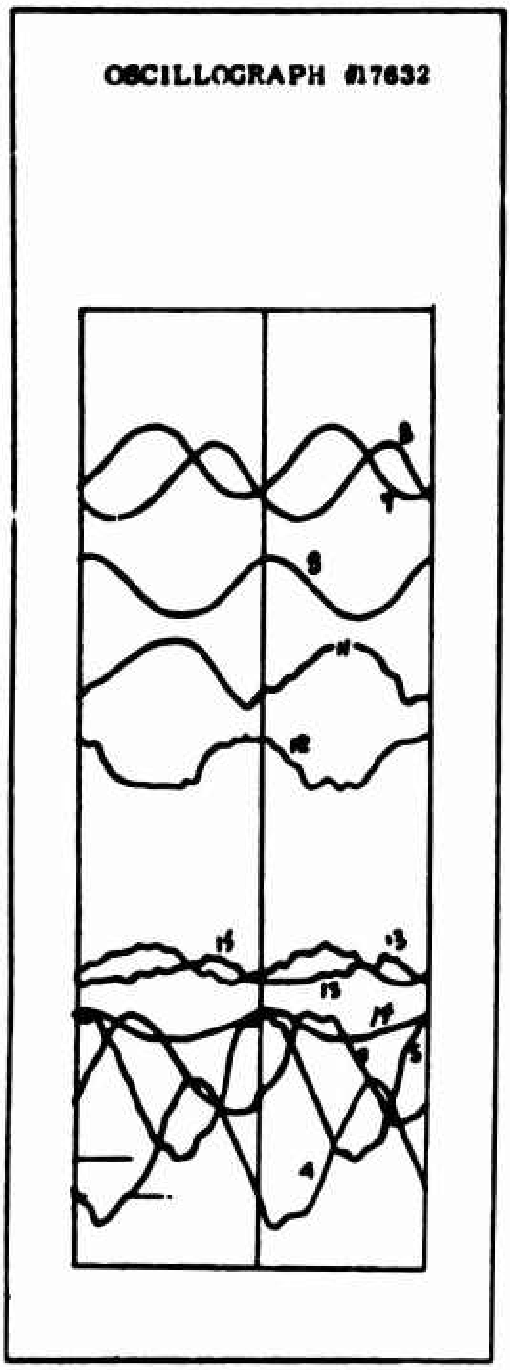
TABLE 19.5a CONFIGURATION J

n = 1.02 V_M = 40.10 MPH ITEM	#17632 & #07632 OSCILLOGRAPH RECORD TR. No.	MAX	MIN	AVE	2A	REDUCED DATA AVE	2A	UNITS	CYC REV.
#1 - Drag Link	1-3	1.40	.78	1.09	.62	- 469.6	64.0	lb	
#2 - Drag Link	1-4	1.04	.22	.63	.82	- 490.7	85.6	lb	
#3 - Drag Link	1-5	1.37	.60	.99	.77	- 441.4	81.3	lb	
#1 - Inbd. Flap	1-10								
#2 - Inbd. Flap	1-11	3.45	3.05	3.28	.45	+ 466.8	477.5	in-lb	
#3 - Inbd. Flap	1-12	2.89	2.63	2.76	.26	+ 186.8	270.0	in-lb	
#1 - Pitch Link	1-13	1.70	1.56	1.63	.14	- 77.8	24.2	lb	
#2 - Pitch Link	1-14	1.40	1.25	1.33	.15	- 57.6	25.4	lb	
#3 - Pitch Link	1-15	1.77	1.55	1.66	.22	- 16.3	40.0	lb	
#1 - Mid Chord	2-6	2.16	1.92	2.04	.24	-3708	494.4	in-lb	
#1 - Mid Flap	2-8	4.20	3.78	3.99	.42	+ 313.9	180.6	in-lb	
#1 - Mid Torsion	2-10	2.64	2.60	2.62	.04	- 103.0	68.6	in-lb	
#1 - Outbd. Flap	2-12	2.72	1.95	2.33	.77	+ 26.7	128.4	in-lb	
Model Attitude	2-11	1.70	1.70	1.70	0	- 4.69		deg	
Collective Pitch	2-13	3.43	3.40	3.42	.03	+ 7.94		deg	
#1 - Cyclic Pitch	1-7	4.59	4.21	4.40	.38	+ 6.67		deg	
#2 - Cyclic Pitch	1-8	4.50	4.09	4.30	.41	+ 7.20		deg	
#3 - Cyclic Pitch	1-9	3.87	3.56	3.71	.31	+ 6.67		deg	
Gyro Roll Pos.	2-3	4.64	4.31	4.47	.33	- 1.45		deg	
Gyro Pitch Pos.	2-5	3.62	3.48	3.55	.14	- 2.93		deg	
Thrust	2-17	1.78	1.75	1.77	.03	+ 339.9		lb	
Drag	2-15	1.12	1.12	1.12	0	- .51		lb	
Roll Moment	2-7	3.88	3.86	3.87	.02			lb	
Pitch Moment	2-9	2.99	2.98	2.99	.01			lb	
Lat. Vibration	2-14	1.64	1.46	1.55	.18		.49	$\frac{ft/sec^2}{G}$	
Long. Vibration	2-16	1.10	.89	1.00	.21		.53		
Vert. Vibration	1-16	1.20	.80	1.00	.40		1.00		

TABLE 19.5b CONFIGURATION J

$n = 1.02$

$V_{M_F} = 40.10$ MPH



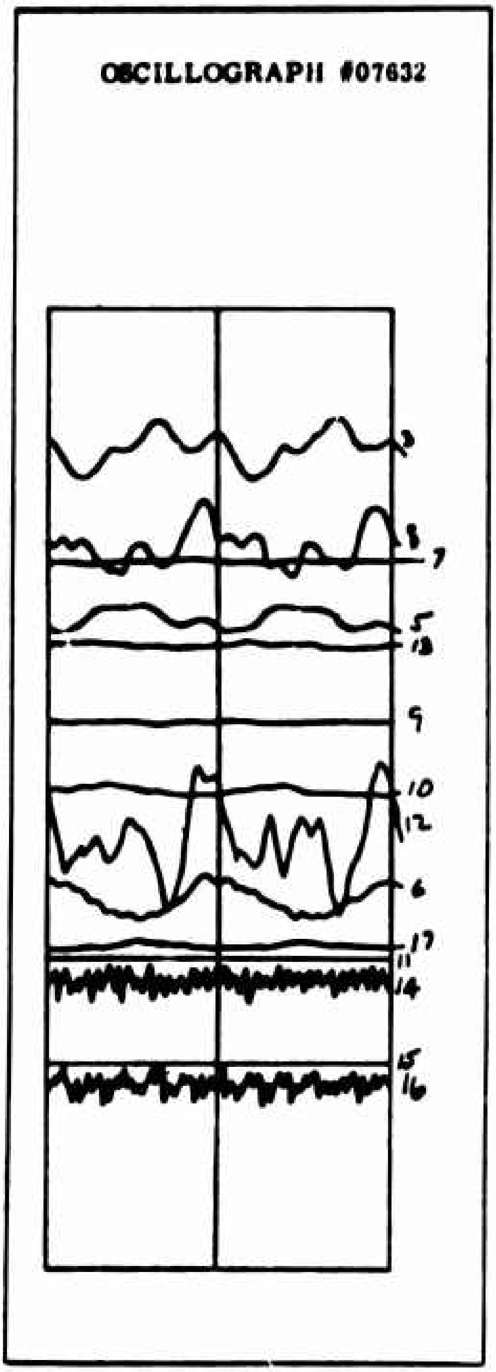


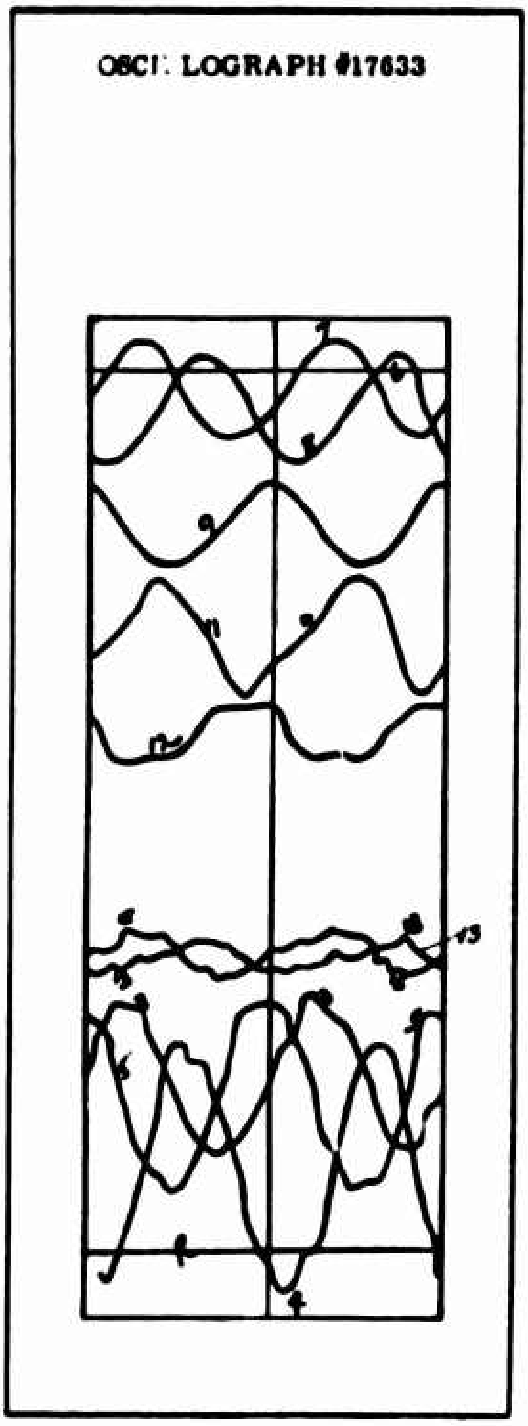
TABLE 19.6a CONFIGURATION J

n = 1.03 V_{K_T} = 50.39 MPH ITEM	#07633 & 17633 OSCILLOGRAPH RECORD					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link	1-3	1.33	.54	.94	.79	- 485.0	81.5	lb	
#2 - Drag Link	1-4	1.14	-.21	.47	1.35	- 507.4	140.9	lb	
#3 - Drag Link	1-5								
#1 - Inbd. Flap	1-10								
#2 - Inbd. Flap	1-11	3.52	2.91	3.22	.61	+ 403.2	647.2	in-lb	
#3 - Inbd. Flap	1-12	2.88	2.56	2.72	.32	+ 145.3	332.2	in-lb	
#1 - Pitch Link	1-13	1.64	1.45	1.55	.19	- 96.6	32.8	lb	
#2 - Pitch Link	1-14	1.30	1.10	1.20	.20	- 113.6	33.9	lb	
#3 - Pitch Link	1-15	1.70	1.43	1.57	.27	- 14.5	49.0	lb	
#1 - Mid Chord	2-6	2.10	1.85	1.98	.25	-3831.6	515.0	in-lb	
#1 - Mid Flap	2-8	4.22	3.76	3.99	.46	+ 313.9	197.8	in-lb	
#1 - Mid Torsion	2-10	2.62	2.57	2.60	.05	- 173.3	85.8	in-lb	
#1 - Outbd. Flap	2-12	3.00	1.82	2.41	1.18	+ 40.0	196.7	in-lb	
Model Attitude	2-11	1.07	1.07	1.07	0	- 8.91		deg	
Collective Pitch	2-13	3.88	3.86	3.87	.02	+ 10.14		deg	
#1 - Cyclic Pitch	1-7	4.78	4.28	4.53	.50	+ 9.7		deg	
#2 - Cyclic Pitch	1-8	4.70	4.16	4.43	.54	+ 12.19		deg	
#3 - Cyclic Pitch	1-9	4.04	3.60	3.82	.44	+ 9.20		deg	
Gyro Roll Pos.	2-3	4.88	4.51	4.70	.37	- .66		deg	
Gyro Pitch Pos.	2-5	3.54	3.35	3.45	.19	- 3.46		deg	
Thrust	2-17	1.80	1.76	1.78	.04	+ 342.8		lb	
Drag	2-15	1.12	1.12	1.12	0	- .51		lb	
Roll Moment	2-7	2.98	2.95	2.97	.03			lb	
Pitch Moment	2-9	3.86	3.85	3.86	.01			lb	
Lat. Vibration	2-14	1.70	1.39	1.55	.31		.84	$\frac{ft/sec^2}{G}$	
Long. Vibration	2-16	1.18	.88	1.03	.30		.75		
Vert. Vibration	1-16								

TABLE 19.6b CONFIGURATION J

$n = 1.03$

$V_{M_F} = 50.39$ MPH



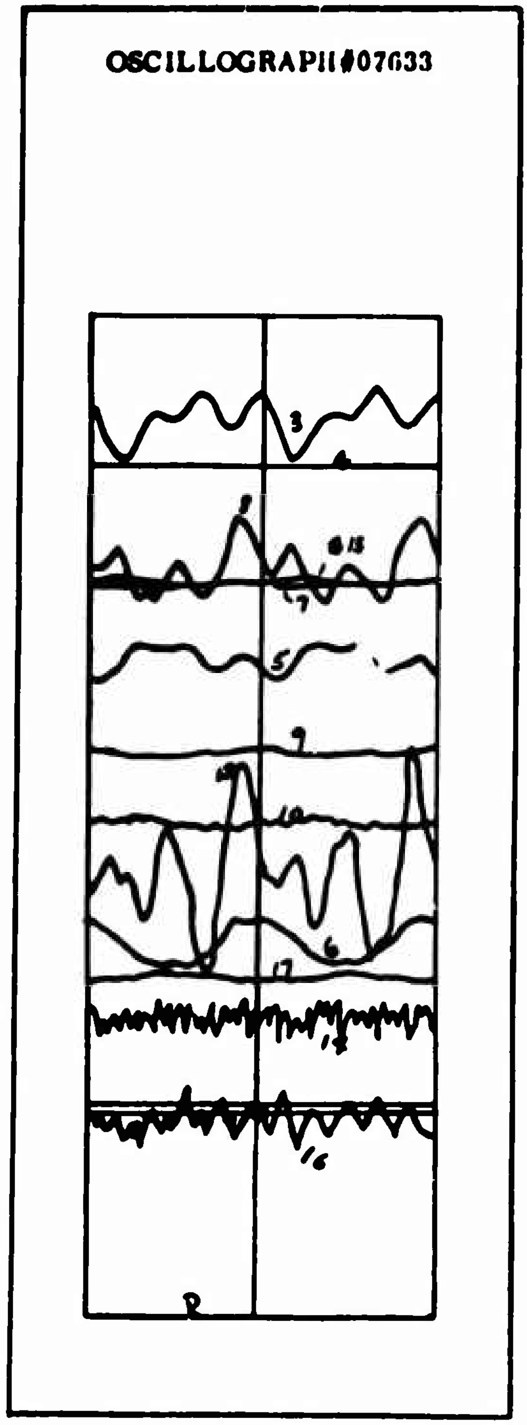


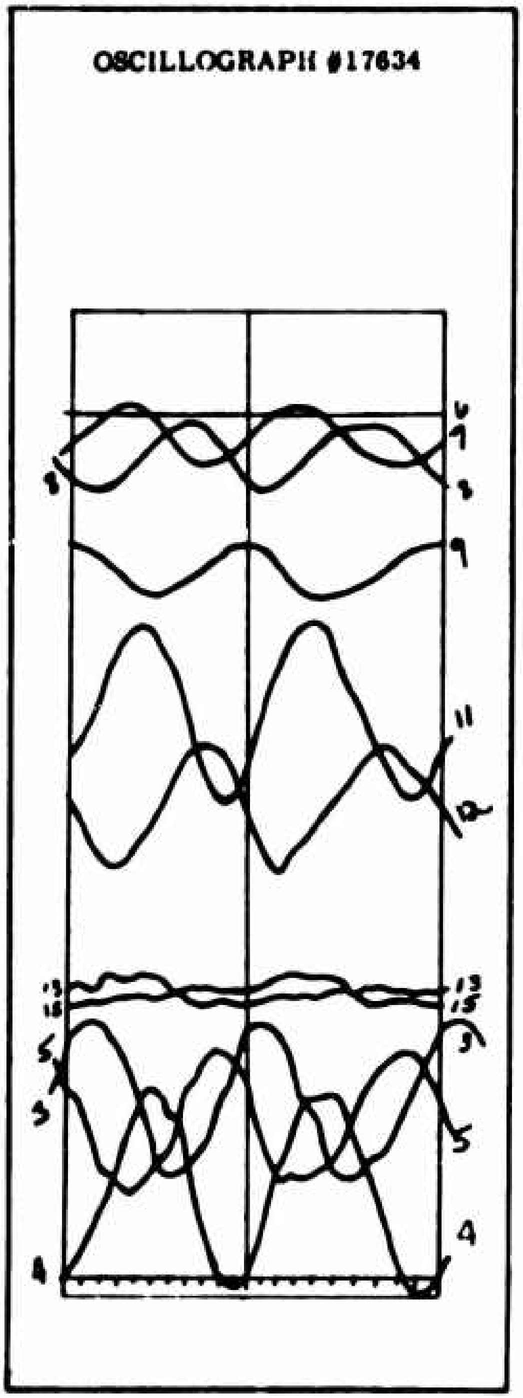
TABLE 19.7a CONFIGURATION J

μ = .46 V_{M_p} = 50.94 MPH ITEM	#17634 & #07634 OSCILLOGRAPH RECORD					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link	1-3	1.38	.55	.97	.83	- 481.9	85.7	lb	
#2 - Drag Link	1-4	1.04	-.08	.48	1.12	- 506.4	50.1	lb	
#3 - Drag Link	1-5	1.24	.52	.88	.72	- 453.0	76.0	lb	
#1 - Inbd. Flap	1-10								
#2 - Inbd. Flap	1-11	3.51	2.57	3.04	.94	+ 212.2	997.3	in-lb	
#3 - Inbd. Flap	1-12	2.87	2.20	2.54	.67	- 41.5	695.5	in-lb	
#1 - Pitch Link	1-13	1.65	1.47	1.56	.18	- 89.9	31.1	lb	
#2 - Pitch Link	1-14	1.28	1.13	1.21	.15	- 111.9	25.4	lb	
#3 - Pitch Link	1-15	1.65	1.47	1.56	.18	- 16.3	32.7	lb	
#1 - Mid Chord	2-6	2.09	1.86	1.98	.23	-3832	473.8	in-lb	
#1 - Mid Flap	2-8	4.11	3.70	3.91	.41	+ 279.5	176.3	in-lb	
#1 - Mid Torsion	2-10	2.64	2.59	2.62	.05	- 103.0	85.8	in-lb	
#1 - Outbd. Flap	2-12	3.18	2.22	2.70	.96	+ 88.4	160.0	in-lb	
Model Attitude	2-11			- .03		- 16.1		deg	
Collective Pitch	2-13	3.87	3.86	3.87	.01	+ 10.1		deg	
#1 - Cyclic Pitch	1-7	4.70	4.39	4.55	.31	+ 10.1		deg	
#2 - Cyclic Pitch	1-8	4.60	4.24	4.42	.36	+ 12.0		deg	
#3 - Cyclic Pitch	1-9	3.97	3.68	3.83	.29	+ 9.4		deg	
Gyro Roll Pos.	2-3	4.82	4.49	4.66	.33	- .79		deg	
Gyro Pitch Pos.	2-5	3.78	3.62	3.70	.16	- 2.15		deg	
Thrust	2-17	1.24	1.21	1.23	.03	+181.7		lb	
Drag	2-15			1.12		- .51		lb	
Roll Moment	2-7	3.88	3.85	3.87	.03			lb	
Pitch Moment	2-9	3.02	2.94	2.98	.08			lb	
Lat. Vibration	2-14	1.68	1.41	1.54	.27		.73	$\frac{ft/sec^2}{G}$	
Long. Vibration	2-16	1.25	.89	1.07	.36		.90		
Vert. Vibration	1-16	1.19	.76	.98	.43		1.08		

TABLE 19.7b CONFIGURATION J

n = .46

V_{M_F} = 50.94 MPH



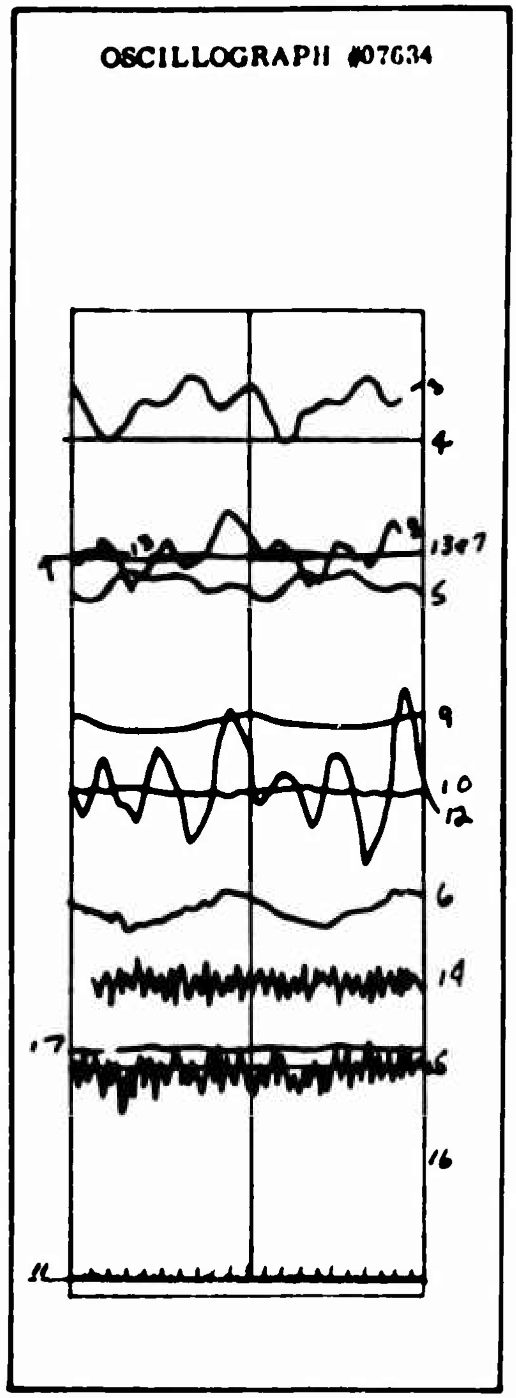


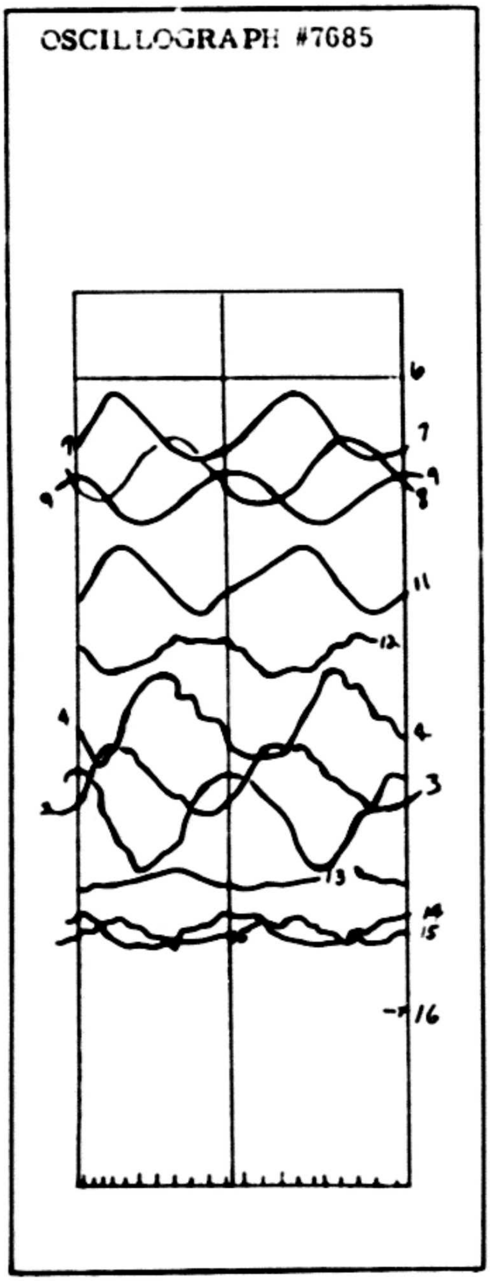
TABLE 20.1a CONFIGURATION K

n = 1.00 V_{M_F} = 39.41 MPH ITEM	#7685 & #07685 OSCILLOGRAPH RECORD					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link #2 - Drag Link #3 - Drag Link	1-3 1-4 1-5	2.60 3.04 2.41	2.18 2.49 1.86	2.39 2.72 2.09	.42 .55 .55	- 345.7 - 287.1 - 324.2	43.3 57.4 58.1	lb	
#1 - Inbd. Flap #2 - Inbd. Flap #3 - Inbd. Flap	1-10 1-11 1-12	 3.76 3.24	 3.37 2.99	 3.57 3.12	 .29 .25	 445.6 218.0	 413.8 259.5	in-lb	
#1 - Pitch Link #2 - Pitch Link #3 - Pitch Link	1-13 1-14 1-15	1.87 1.62 1.50	1.7- 1.40 1.43	1.81 1.51 1.51	.13 .22 .15	- 67.4 - 66.1 - 19.97	22.46 37.39 27.24	lb	
#1 - Mid Chord #1 - Mid Flap #1 - Mid Torsion #1 - Outbd. Flap	2-6 2-8 2-10 2-12	2.80 4.58 2.97 3.22	2.63 4.21 2.92 2.33	2.72 4.40 2.95 2.78	.17 .37 .05 .89	-3790 275 - 205.9 58.3	350.2 159.1 85.8 148.4	in-lb	
Model Attitude Collective Pitch #1 - Cyclic Pitch #2 - Cyclic Pitch #3 - Cyclic Pitch	2-11 2-13 1-7 1-8 1-9	2.02 2.77 4.65 4.40 4.20	2.02 2.75 4.29 4.03 3.91	2.02 2.76 4.47 4.22 4.02	0 .02 .36 .37 .29	- 3.69 3.72 2.76 4.14 4.83		deg	
Gyro Roll Pos. Gyro Pitch Pos.	2-3 2-5	5.37 4.33	5.12 4.22	5.25 4.28	.25 .11	.17 - 2.93		deg	
Thrust Drag Roll Moment Pitch Moment	2-17 2-15 2-7 2-9	1.73 1.28 4.04 3.39	1.71 1.28 4.01 3.38	1.72 1.28 4.03 3.39	.02 0 .03 .01	313., 0		lb	
Lat. Vibration Long. Vibration Vert. Vibration	2-14 2-16 1-16	1.74 1.11 1.10	1.57 .83 .81	1.66 .97 .96	.17 .28 .29		.459 .70 .725	$\frac{ft/sec^2}{G}$	

TABLE 20.1b CONFIGURATION K

$n = 1.00$

$V_{M_F} = 39.41$ MPH



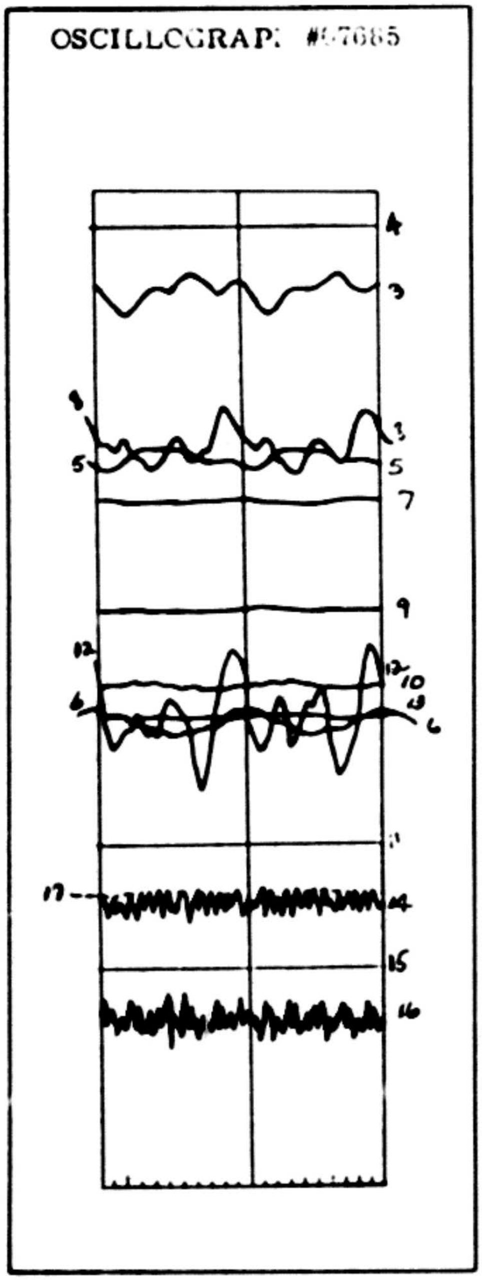


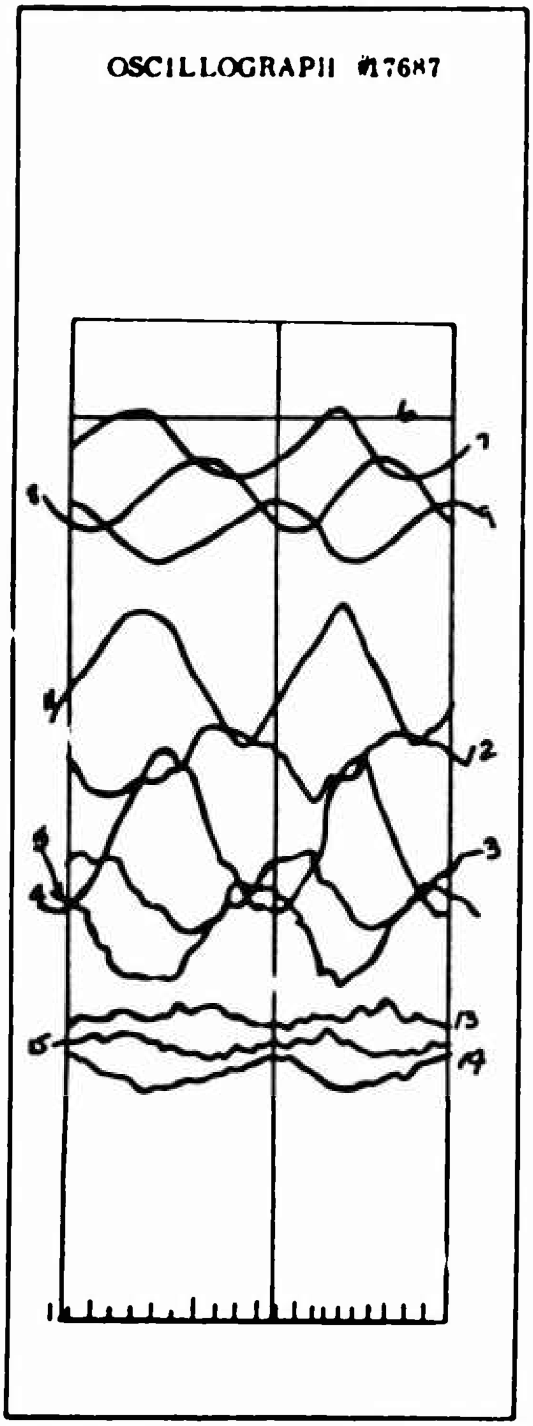
TABLE 20.2a CONFIGURATION K

n = .50 V_{M_F} = 53.51 MPH ITEM	#17687 & #07687 OSCILLOGRAPH RECORD					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link	1-3	2.46	2.04	2.25	.42	- 360.2	43.3	lb	
#2 - Drag Link	1-4	2.99	2.14	2.57	.85	- 302.8	88.7	lb	
#3 - Drag Link	1-5	2.27	1.75	2.01	.52	- 332.7	54.9	lb	
#1 - Inbd. Flap	1-10								
#2 - Inbd. Flap	1-11	3.75	3.02	3.39	.73	+ 254.6	774.5	in-lb	
#3 - Inbd. Flap	1-12	3.11	2.72	2.92	.39	+ 10.4	404.8	in-lb	
#1 - Pitch Link	1-13	1.68	1.54	1.61	.14	- 101.9	24.2	lb	
#2 - Pitch Link	1-14	1.40	1.19	1.30	.21	- 101.7	35.6	lb	
#3 - Pitch Link	1-15	1.52	1.37	1.45	.15	- 30.9	27.2	lb	
#1 - Mid Chord	2-6	2.75	2.58	2.67	.17	-3893.4	350.2	in-lb	
#1 - Mid Flap	2-8	4.52	4.18	4.35	.34	+ 253.7	146.2	in-lb	
#1 - Mid Torsion	2-10	2.95	2.92	2.94	.03	- 223.1	51.5	in-lb	
#1 - Outbd. Flap	2-12	3.60	2.67	3.14	.93	+ 118.4	155.0	in-lb	
Model Attitude	2-11	.67	.67	.67	0	- 12.73		deg	
Collective Pitch	2-13	3.20	3.17	3.19	.03	+ 5.83		deg	
#1 - Cyclic Pitch	1-7	4.79	4.44	4.62	.35	+ 6.21		deg	
#2 - Cyclic Pitch	1-8	4.53	4.15	4.34	.38	+ 6.90		deg	
#3 - Cyclic Pitch	1-9	4.31	3.98	4.15	.33	+ 6.90		deg	
Gyro Roll Pos.	2-3	5.60	5.32	5.46	.28	+ .90		deg	
Gyro Pitch Pos.	2-5	4.44	4.27	4.36	.17	- 2.52		deg	
Thrust	2-17	1.19	1.16	1.18	.03	155.3		lb	
Drag	2-15	1.27	1.26	1.27	.01	+ .25		lb	
Roll Moment	2-7	4.03	4.00	4.02	.03			lb	
Pitch Moment	2-9	3.34	3.24	3.29	.10			lb	
Lat. Vibration	2-14	1.74	1.52	1.63	.22		.59	$\frac{ft/sec^2}{G}$	
Long. Vibration	2-16	1.20	.88	1.04	.32		.80		
Vert. Vibration	1-16								

TABLE 20.2b CONFIGURATION K

$n = .50$

$V_{M_F} = 53.51$ MPH



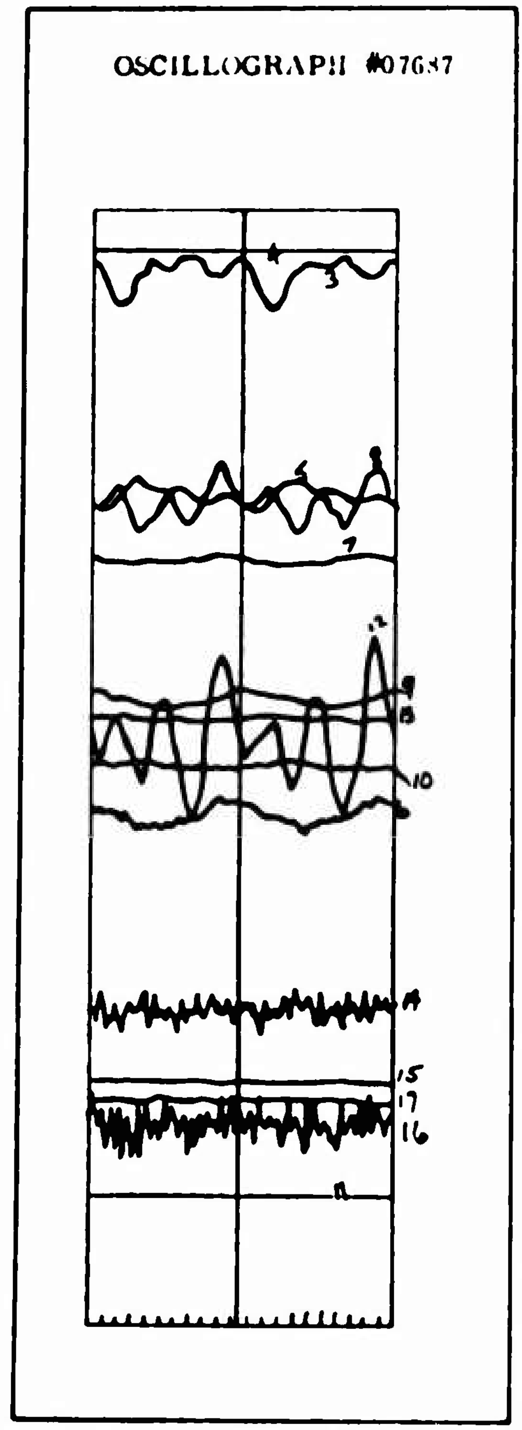


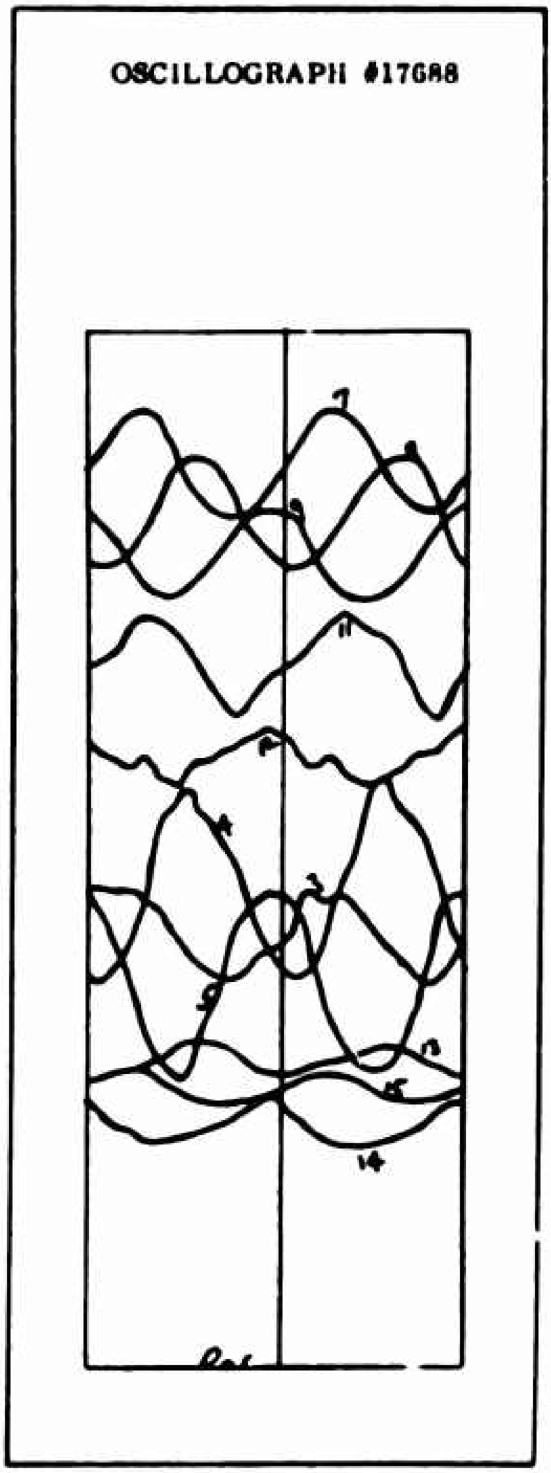
TABLE 20.3a CONFIGURATION K

n = 1.10 V_{M_F} = 54.13 MPH ITEM	#17688 & #07688 OSCILLOGRAPH RECORD					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link	1-3	2.44	1.96	2.20	.48	- 365.3	49.5	lb	
#2 - Drag Link	1-4	3.01	1.95	2.48	1.06	- 312.2	110.7	lb	
#3 - Drag Link	1-5	2.42	1.4[illegible]	1.95	.95	- 339.0	100.3	lb	
#1 - Inbd. Flap	1-10								
#2 - Inbd. Flap	1-11	3.84	3.31	3.58	.53	+ 456.2	562.3	in-lb	
#3 - Inbd. Flap	1-12	3.25	2.97	3.11	.28	+ 207.6	290.6	in-lb	
#1 - Pitch Link	1-13	1.68	1.49	1.59	.19	- 105.4	32.8	lb	
#2 - Pitch Link	1-14	1.38	1.14	1.26	.24	- 108.5	40.7	lb	
#3 - Pitch Link	1-15	1.53	1.35	1.44	.18	32.7	22.7	lb	
#1 - Mid Chord	2-6	2.77	2.53	2.65	.24	-3934.6	494.4	in-lb	
#1 - Mid Flap	2-8	4.62	4.10	4.36	.52	+ 258.0	223.6	in-lb	
#1 - Mid Torsion	2-10	2.96	2.88	2.92	.08	- 257.4	137.3	in-lb	
#1 - Outbd. Flap	2-12	3.50	2.22	2.86	1.28	+ 71.7	213.4	in-lb	
Model Attitude	2-11			1.74		- 5.6		deg	
Collective Pitch	2-13	3.18	3.15	3.17	.03	+ 5.7		deg	
#1 - Cyclic Pitch	1-7	4.88	4.34	4.61	.54	+ 6.0		deg	
#2 - Cyclic Pitch	1-8	4.64	4.08	4.36	.56	+ 7.4		deg	
#3 - Cyclic Pitch	1-9	4.39	3.91	4.15	.48	+ 6.9		deg	
Gyro Roll Pos.	2-3	5.63	5.32	5.48	.31	+ .97		deg	
Gyro Pitch Pos.	2-5	4.20	3.99	4.10	.21	- 3.9		deg	
Thrust	2-17	1.81	1.78	1.80	.03	+ 337.0		lb	
Drag	2-15			1.26		- .51		lb	
Roll Moment	2-7	3.95	3.92	3.94	.03			lb	
Pitch Moment	2-9	3.34	3.32	3.33	.02			lb	
Lat. Vibration	2-14	1.75	1.55	1.65	.20		.54	$\frac{ft/sec^2}{G}$	
Long. Vibration	2-16	1.10	.90	1.00	.20		.50		
Vert. Vibration	1-16	1.22	.80	1.01	.42		1.05		

TABLE 20.3b CONFIGURATION K

$n = 1.10$

$V_{M_F} = 54.13$ MPH



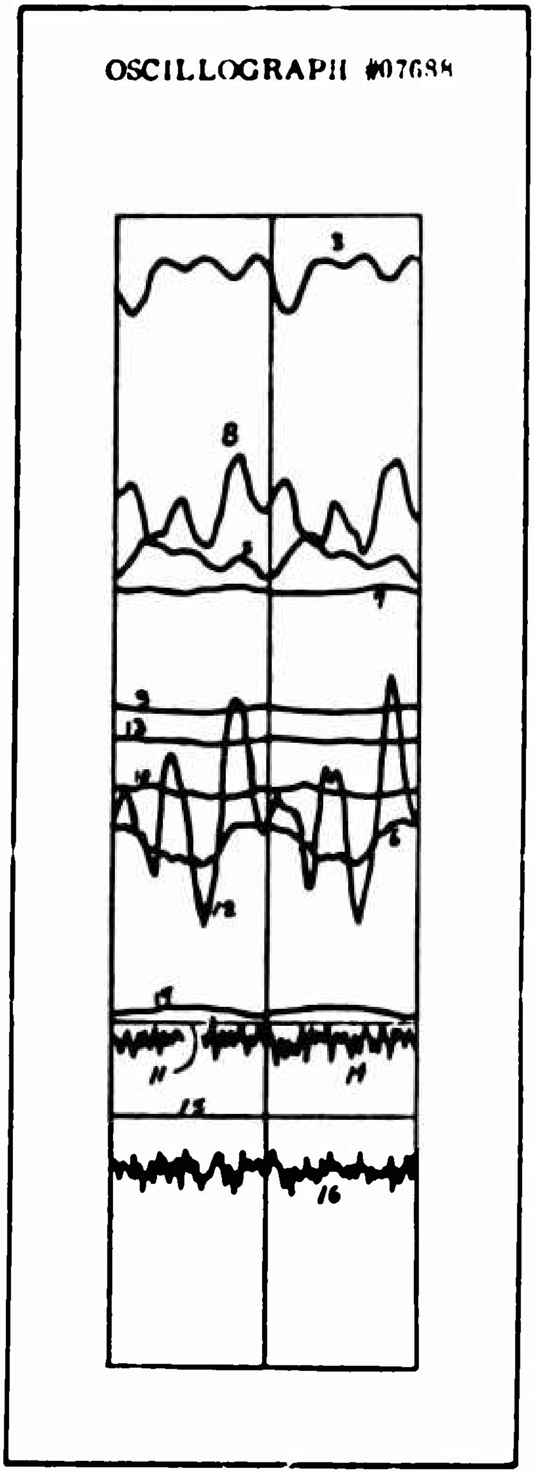


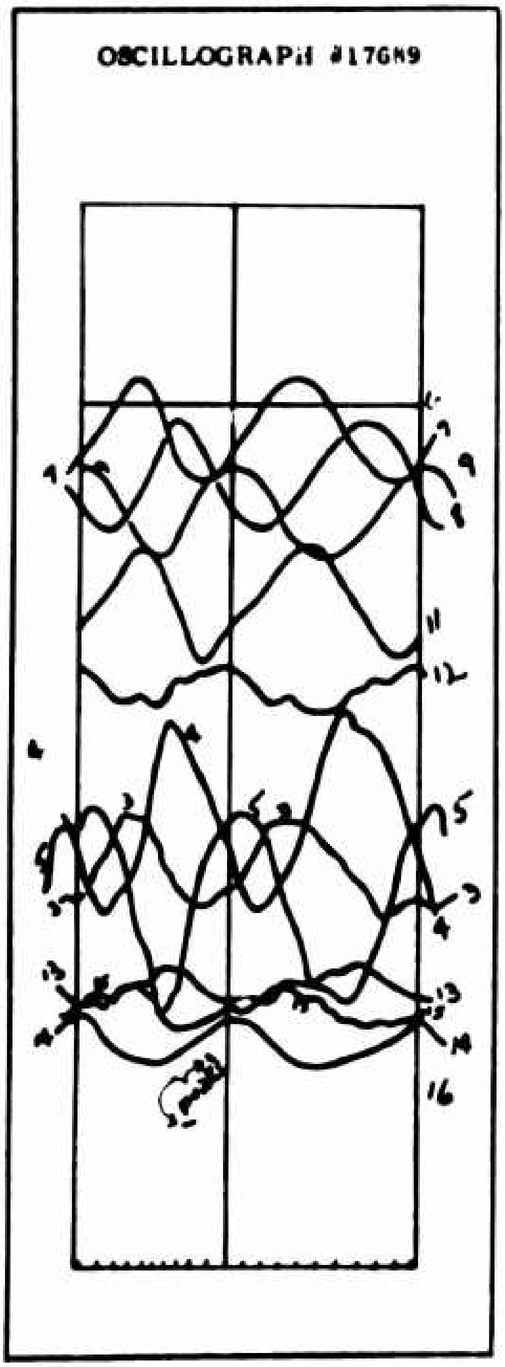
TABLE 20.4: CONFIGURATION K

V_{M_F} MPH ITEM	#1708 & #1709 OSCILLOGRAPH RECORD TR. No.	MAX	MIN	AVE	2A	REDUCED DATA AVE	2A	UNITS	CYC REV.
#1 - Drag Link	1-3	2.50	1.93	2.22	.57	- 363.3	58.8	lb	
#2 - Drag Link	1-4	3.08	1.96	2.52	1.12	- 398.0	116.9	lb	
#3 - Drag Link	1-5	2.53	1.43	1.98	1.10	- 577.5	116.2	lb	
#1 - Inbd. Flap	1-10								
#2 - Inbd. Flap	1-11	3.97	3.34	3.66	.63	+ 541.1	668.4	in-lb	
#3 - Inbd. Flap	1-12	3.30	3.08	3.19	.22	+ 290.6	228.4	in-lb	
#1 - Pitch Link	1-13	1.67	1.42	1.55	.25	- 112.3	43.2	lb	
#2 - Pitch Link	1-14	1.39	1.11	1.25	.28	- 110.2	47.5	lb	
#3 - Pitch Link	1-15	1.56	1.32	1.44	.24	- 32.7	43.6	lb	
#1 - Mid Chord	2-6	2.78	2.53	2.66	.25	-3914	515.0	in-lb	
#1 - Mid Flap	2-8	4.68	4.18	4.43	.50	+ 288.1	215.0	in-lb	
#1 - Mid Torsion	2-10	2.95	2.89	2.92	.06	- 257.4	103.0	in-lb	
#1 - Outbd. Flap	2-12	3.44	2.10	2.77	1.34	+ 56.7	223.4	in-lb	
Model Attitude	2-11	2.06	2.06	2.06	0	- 3.42		deg	
Collective Pitch	2-13	3.20	3.17	3.19	.03	+ 5.83		deg	
#1 - Cyclic Pitch	1-7	4.39	4.33	4.61	.05	+ .26		deg	
#2 - Cyclic Pitch	1-8	4.66	4.05	4.36	.01	+ 7.36		deg	
#3 - Cyclic Pitch	1-9	4.40	3.90	4.15	.50	+ 6.90		deg	
Gyro Roll Pos.	2-3	5.65	5.32	5.49	.33	+ 1.00		deg	
Gyro Pitch Pos.	2-5	4.17	3.96	4.07	.21	- 4.03		deg	
Thrust	2-17	2.05	2.01	2.03	.04	+ 404.3		lb	
Drag	2-15	1.27	1.27	1.27	0	- .25		lb	
Roll Moment	2-7	3.93	3.89	3.91	.04			lb	
Pitch Moment	2-9	3.40	3.39	3.40	.01			lb	
Lat. Vibration	2-14	1.75	1.44	1.60	.31		.837	ft/sec²/G	
Long. Vibration	2-16	1.08	.86	.97	.22		.55	ft/sec²/G	
Vert. Vibration	1-16	1.15	.78	.97	.37		.925	ft/sec²/G	

TABLE 20.4b CONFIGURATION K

$n = 1.29$

$V_{M_F} = 54.38$ MPH



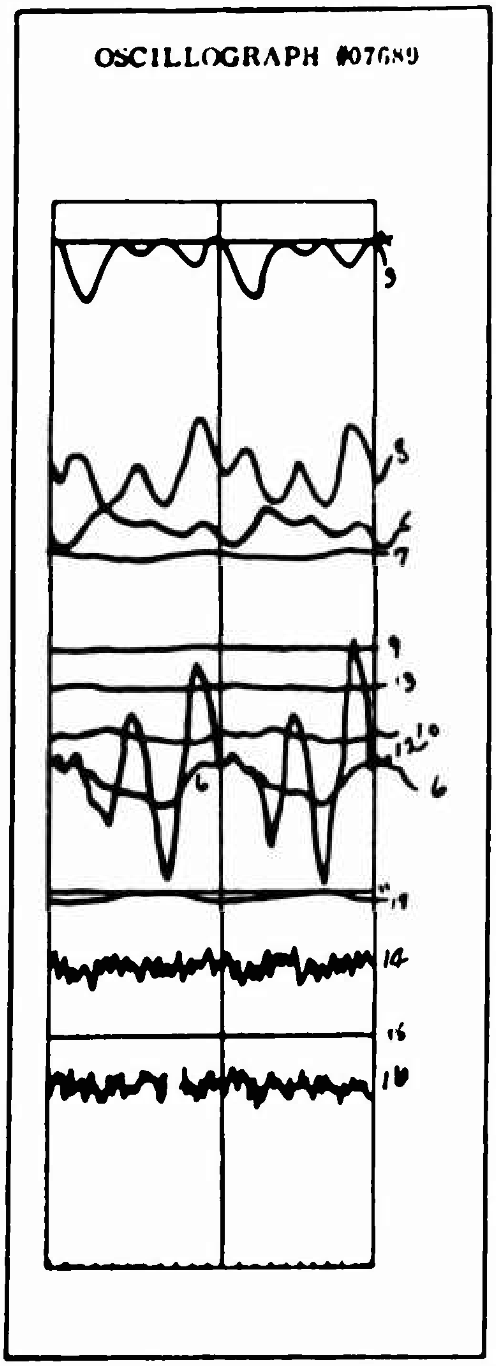
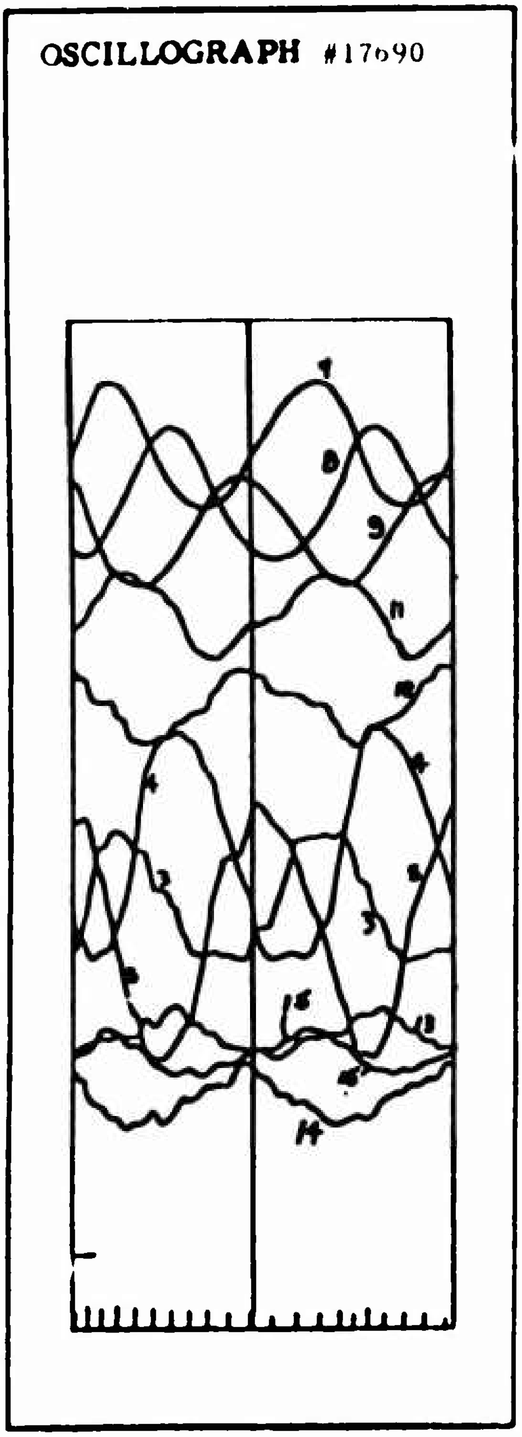


TABLE 20.5a CONFIGURATION K

n = 1.51 V_{M_F} = 54.69 MPH ITEM	OSCILLOGRAPH RECORD (#17690 & #07690)					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link	1-3	2.60	1.91	2.25	.69	- 356	71.2		
#2 - Drag Link	1-4	3.14	1.89	2.51	1.25	- 309	130.5	lb	
#3 - Drag Link	1-5	2.73	1.39	2.06	1.34	- 327.4	141.5		
#1 - Inbd. Flap	1-10								
#2 - Inbd. Flap	1-11	3.93	3.48	3.71	.45	594.2	477.5	in-lb	
#3 - Inbd. Flap	1-12	3.42	3.05	3.23	.37	332.2	384.1		
#1 - Pitch Link	1-13	1.70	1.41	1.56	.29	- 110.6	50.1		
#2 - Pitch Link	1-14	1.38	1.05	1.22	.33	- 115.3	56.0	lb	
#3 - Pitch Link	1-15	1.56	1.31	1.43	.25	- 34.5	45.4		
#1 - Mid Chord	2-6	2.79	2.49	2.64	.30	-3955.2	618.0		
#1 - Mid Flap	2-8	4.64	4.08	4.36	.56	258	240.8	in-lb	
#1 - Mid Torsion	2-10	2.94	2.88	2.91	.06	- 274.6	103.0		
#1 - Outbd. Flap	2-12	3.40	2.01	2.71	1.39	46.7	231.7		
Model Attitude	2-11			2.49		- .54			
Collective Pitch	2-13	3.19	3.15	3.17	.04	5.73			
#1 - Cyclic Pitch	1-7	4.93	4.28	4.61	.65	5.98		deg	
#2 - Cyclic Pitch	1-8	4.69	4.01	4.35	.68	7.13			
#3 - Cyclic Pitch	1-9	4.43	3.88	4.15	.55	6.90			
Gyro Roll Pos.	2-3	5.67	5.34	5.51	.33	1.07		deg	
Gyro Pitch Pos.	2-5	4.06	3.53	3.80	.53	- 5.45			
Thrust	2-17	2.30	2.25	2.28	.05	477.6			
Drag	2-15			1.27		- .25			
Roll Moment	2-7	3.91	3.87	3.89	.04			lb	
Pitch Moment	2-9		3.23						
Lat. Vibration	2-14	1.72	1.54	1.63	.18		.486		
Long. Vibration	2-16	1.08	.88	.98	.20		.50	$\frac{ft/sec^2}{G}$	
Vert. Vibration	1-16	1.17	.78	.97	.39		.975		

$n = 1.51$

$V_{M_F} = 54.69$ MPH



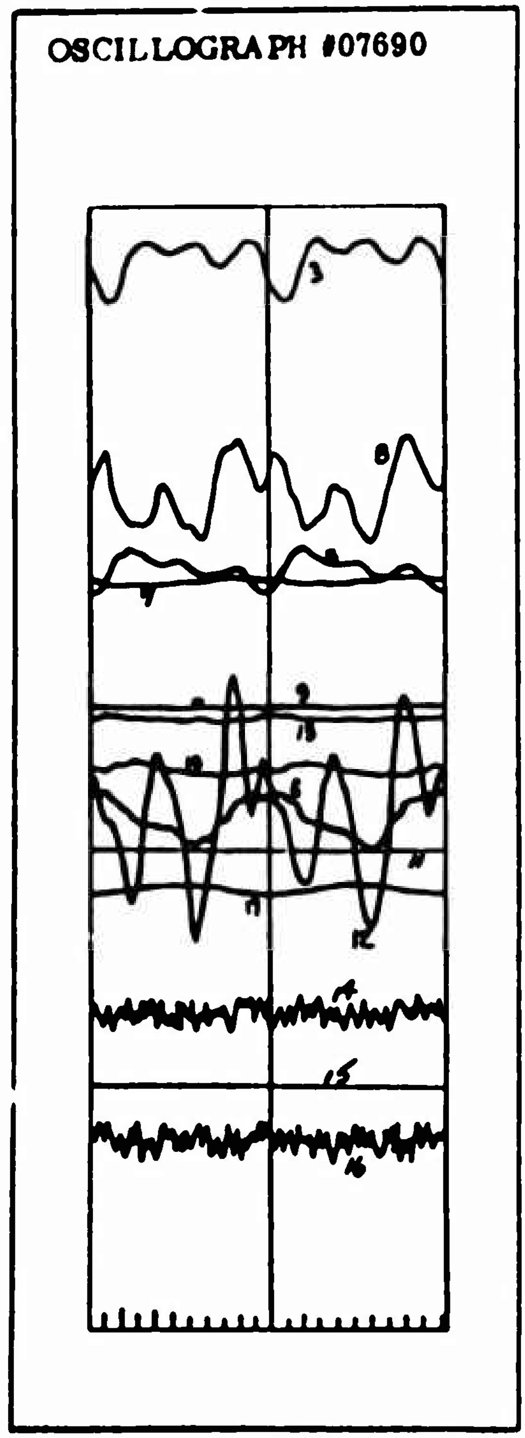


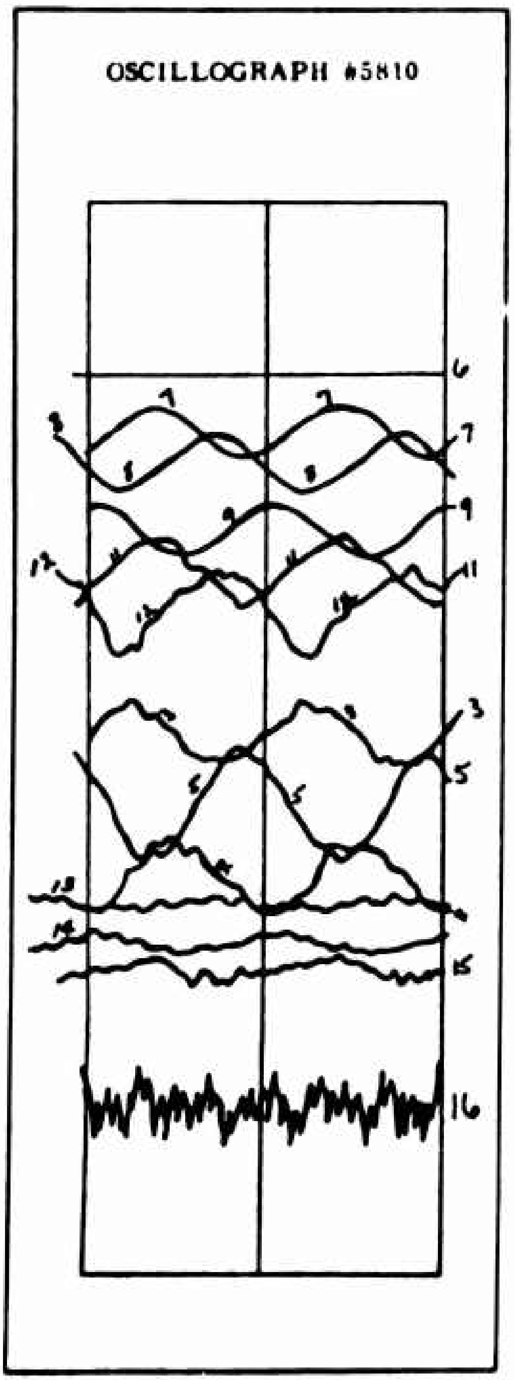
TABLE 21.1a CONFIGURATION L

n = .55 V_{M_F} = 42.29 MPH ITEM	#5810 & #7810 OSCILLOGRAPH RECORD					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link	1-3	3.12	2.78	2.95	.34	- 302.6	34.8	lb	
#2 - Drag Link	1-4	2.36	1.96	2.16	.40	- 365.9	43.3	lb	
#3 - Drag Link	1-5	2.86	2.25	2.56	.61	- 296.5	65.3	lb	
#1 - Inbd. Flap	1-10								
#2 - Inbd. Flap	1-11	4.03	3.62	3.83	.41	+ 636.6	435.0	in-lb	
#3 - Inbd. Flap	1-12	3.84	3.36	3.60	.48	+ 668.4	509.3	in-lb	
#1 - Pitch Link	1-13	2.06	1.98	2.01	.08	- 48.9	13.97	lb	
#2 - Pitch Link	1-14	1.85	1.75	1.80	.10	- 36.7	17.5	lb	
#3 - Pitch Link	1-15	1.72	1.58	1.65	.14	- 21.0	24.5	lb	
#1 - Mid Chord	2-6	2.66	2.46	2.56	.20	+3214	412.0	in-lb	
#1 - Mid Flap	2-8	4.16	3.90	4.03	.26	+ 230.0	110.8	in-lb	
#1 - Mid Torsion	2-10	3.00	2.96	2.98	.04	+ 23.6	47.3	in-lb	
#1 - Outbd. Flap	2-12	2.97	2.20	2.59	.77	+ 84.2	120.1	in-lb	
Model Attitude	2-11	1.20	1.20	1.20	0	- 8.64		deg	
Collective Pitch	2-13	2.46	2.43	2.45	.03	+ 3.14		deg	
#1 - Cyclic Pitch	1-7	4.70	4.45	4.58	.25	+ 2.38		deg	
#2 - Cyclic Pitch	1-8	4.58	4.27	4.43	.31	+ 3.28		deg	
#3 - Cyclic Pitch	1-9	4.17	3.92	4.05	.25	+ 2.89		deg	
Gyro Roll Pos.	2-3	5.49	5.23	5.36	.26	+ .55		deg	
Gyro Pitch Pos.	2-5	4.34	4.14	4.24	.20	- 1.99		deg	
Thrust	2-17	1.18	1.15	1.17	.03	+ 161.2		lb	
Drag	2-15	1.20	1.20	1.20	0	- .76		lb	
Roll Moment	2-7	3.82	3.80	3.81	.02			lb	
Pitch Moment	2-9	3.16	3.12	3.14	.04			lb	
Lat. Vibration	2-14	1.73	1.51	1.62	.22		.59	$\frac{ft/sec^2}{G}$	
Long. Vibration	2-16	1.21	.89	1.05	.32		.80		
Vert. Vibration	1-16	1.12	.70	.91	.42		1.05		

TABLE 21.1b CONFIGURATION L

$n = .55$

$V_{M_F} = 42.29$ MPH



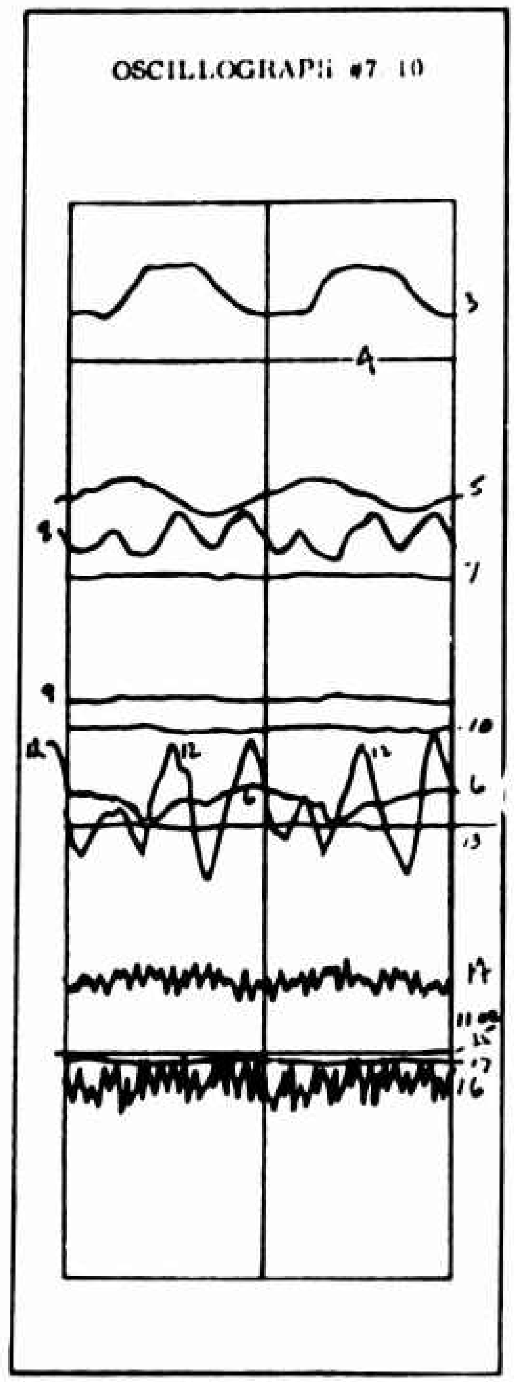


TABLE 21.2a CONFIGURATION L

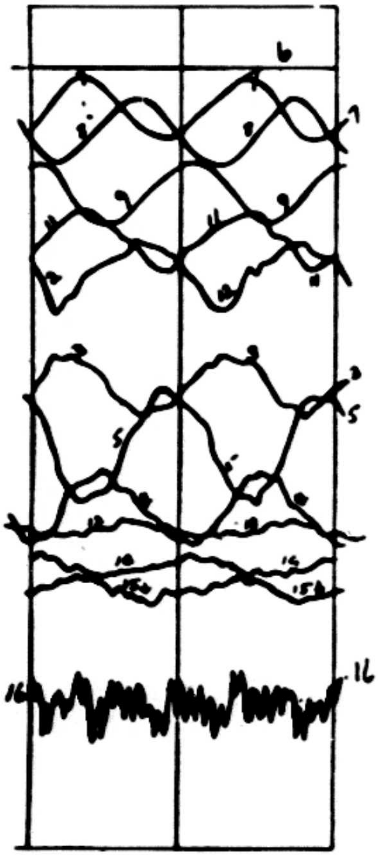
n = .53 V_{M_F} = 53.56 MPH ITEM	#5811 & #7811 OSCILLOGRAPH RECORD					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link	1-3	3.10	2.72	2.91	.38	- 306.7	38.9	lb	
#2 - Drag Link	1-4	2.37	1.90	2.14	.47	- 368.1	50.9	lb	
#3 - Drag Link	1-5	2.89	2.17	2.53	.72	- 299.7	77.1	lb	
#1 - Inbd. Flap	1-10								
#2 - Inbd. Flap	1-11	4.00	3.61	3.81	.39	+ 615.4	413.8	in-lb	
#3 - Inbd. Flap	1-12	3.81	3.35	3.58	.46	+ 647.2	488.1	in-lb	
#1 - Pitch Link	1-13	2.06	1.98	2.02	.08	- 47.2	14.0	lb	
#2 - Pitch Link	1-14	1.83	1.71	1.77	.12	- 41.9	21.0	lb	
#3 - Pitch Link	1-15	1.69	1.53	1.61	.16	- 27.9	27.9	lb	
#1 - Mid Chord	2-6	2.71	2.37	2.54	.34	-3254.8	700.4	in-lb	
#1 - Mid Flap	2-8	4.22	3.88	4.05	.34	+ 238.6	144.8	in-lb	
#1 - Mid Torsion	2-10	3.00	2.97	2.99	.03	+ 35.5	35.5	in-lb	
#1 - Outbd. Flap	2-12	3.08	2.02	2.05	.06	0	9.36	in-lb	
Model Attitude	2-11	1.20	1.20	1.20	0	- 8.64		deg	
Collective Pitch	2-13	2.67	2.64	2.66	.03	+ 4.17		deg	
#1 - Cyclic Pitch	1-7	4.83	4.47	4.65	.36	+ 3.36		deg	
#2 - Cyclic Pitch	1-8	4.71	4.29	4.50	.42	+ 4.16		deg	
#3 - Cyclic Pitch	1-9	4.29	3.92	4.11	.37	+ 3.80		deg	
Gyro Roll Pos.	2-3	5.64	5.32	5.48	.32	+ .97		deg	
Gyro Pitch Pos.	2-5	4.26	4.04	4.15	.22	- 2.46		deg	
Thrust	2-17	1.15	1.13	1.14	.02	+152.4		lb	
Drag	2-15	1.21	1.21	1.21	0	- .51		lb	
Roll Moment	2-7	3.79	3.77	3.78	.02			lb	
Pitch Moment	2-9	3.14	3.08	3.11	.06			lb	
Lat. Vibration	2-14	1.71	1.52	1.62	.19		.51	$\frac{ft/sec^2}{G}$	
Long. Vibration	2-16	1.21	.91	1.06	.30		.75		
Vert. Vibration	1-16	1.10	.68	.89	.42		1.05		

TABLE 21.2b CONFIGURATION L

$n = .53$

$V_{M_F} = 53.56$ MPH

OSCILLOGRAPH #5811



OSCILLOGRAPH #7811

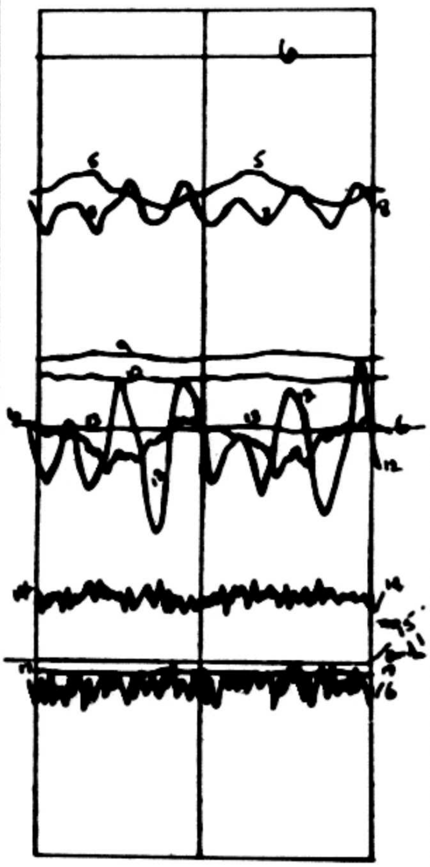


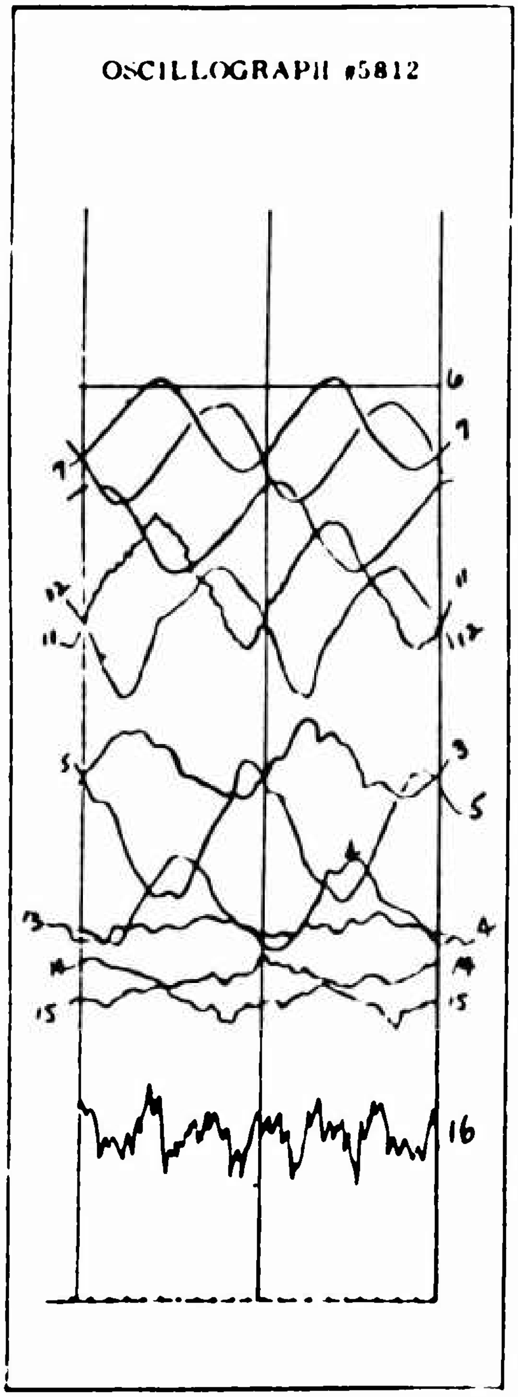
TABLE 21.3a CONFIGURATION L

$n = .59$ $V_{M_F} = 68.53$ MPH ITEM	#5812 & #7812 OSCILLOGRAPH RECORD					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link	1-3	3.11	2.69	2.90	.42	- 307.7	43.3	lb	
#2 - Drag Link	1-4	2.37	1.88	2.13	.49	- 369.1	51.2	lb	
#3 - Drag Link	1-5	2.89	2.12	2.51	.77	- 301.9	81.3	lb	
#1 - Inbd. Flap	1-10								
#2 - Inbd. Flap	1-11	4.20	3.48	3.84	.72	+ 647.2	763.9	in-lb	
#3 - Inbd. Flap	1-12	3.92	3.22	3.57	.70	+ 636.6	742.7	in-lb	
#1 - Pitch Link	1-13	2.08	1.95	2.02	.13	- 47.2	22.7	lb	
#2 - Pitch Link	1-14	1.85	1.70	1.77	.15	- 41.9	26.2	lb	
#3 - Pitch Link	1-15	1.69	1.50	1.60	.19	- 29.7	33.2	lb	
#1 - Mid Chord	2-6	2.76	2.26	2.51	.50	-3317	1030	in-lb	
#1 - Mid Flap	2-8	4.36	3.78	4.07	.58	+ 247.1	247.1	in-lb	
#1 - Mid Torsion	2-10	3.00	2.96	2.98	.04	+ 23.6	47.3	in-lb	
#1 - Outbd. Flap	2-12	3.38	1.72	2.55	1.66	+ 78.0	259.0	in-lb	
Model Attitude	2-11	1.46	1.46	1.46	0	- 6.90		deg	
Collective Pitch	2-13	2.82	2.80	2.81	.02	+ 4.9		deg	
#1 - Cyclic Pitch	1-7	4.93	4.45	4.69	.48	+ 3.92		deg	
#2 - Cyclic Pitch	1-8	4.80	4.77	4.79	.03	+ 7.81		deg	
#3 - Cyclic Pitch	1-9	4.37	3.90	4.14	.47	+ 4.26		deg	
Gyro Roll Pos.	2-3	5.81	5.37	5.59	.44	+ 1.35		deg	
Gyro Pitch Pos.	2-5	4.20	3.92	4.06	.28	- 2.93		deg	
Thrust	2-17	1.27	1.25	1.26	.02	+ 187.5		lb	
Drag	2-15	1.82	1.82	1.82	0	+ 15.0		lb	
Roll Moment	2-7	3.69	3.66	3.68	.03			lb	
Pitch Moment	2-9	3.25	3.24	3.25	.01			lb	
Lat. Vibration	2-14	1.74	1.49	1.62	.25		.675	$\frac{ft/sec^2}{G}$	
Long. Vibration	2-16	1.15	.94	1.05	.21		.525		
Vert. Vibration	1-16	1.17	.61	.89	.56		1.40		

TABLE 21.3b CONFIGURATION L

$n = .59$

$V_{\lambda_F} = 68.53$ MPH



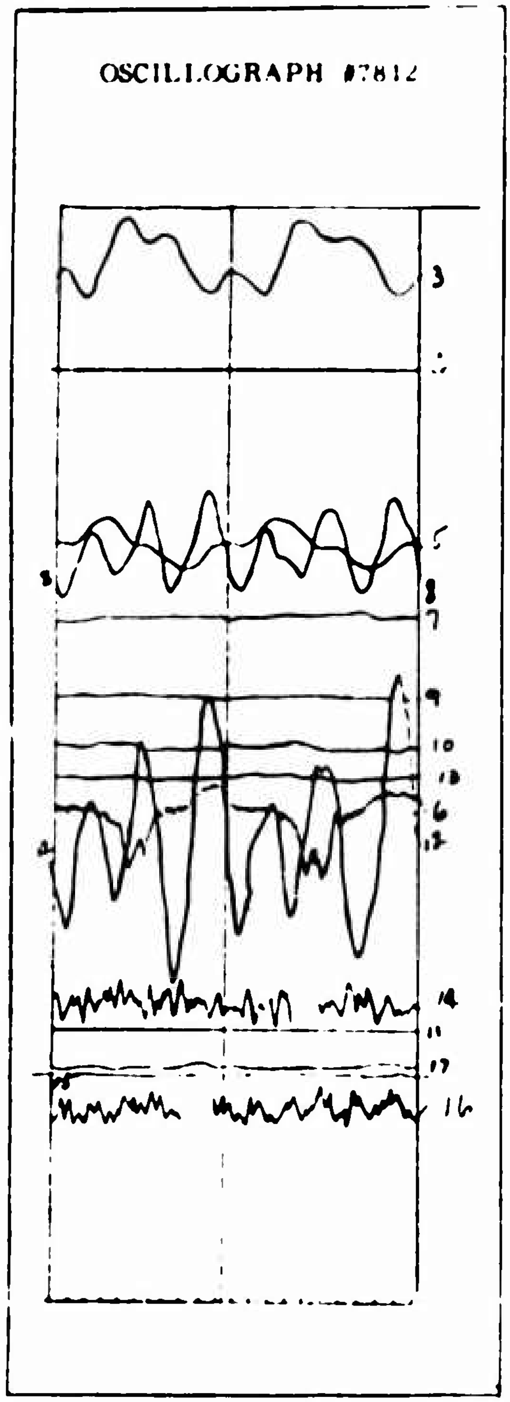


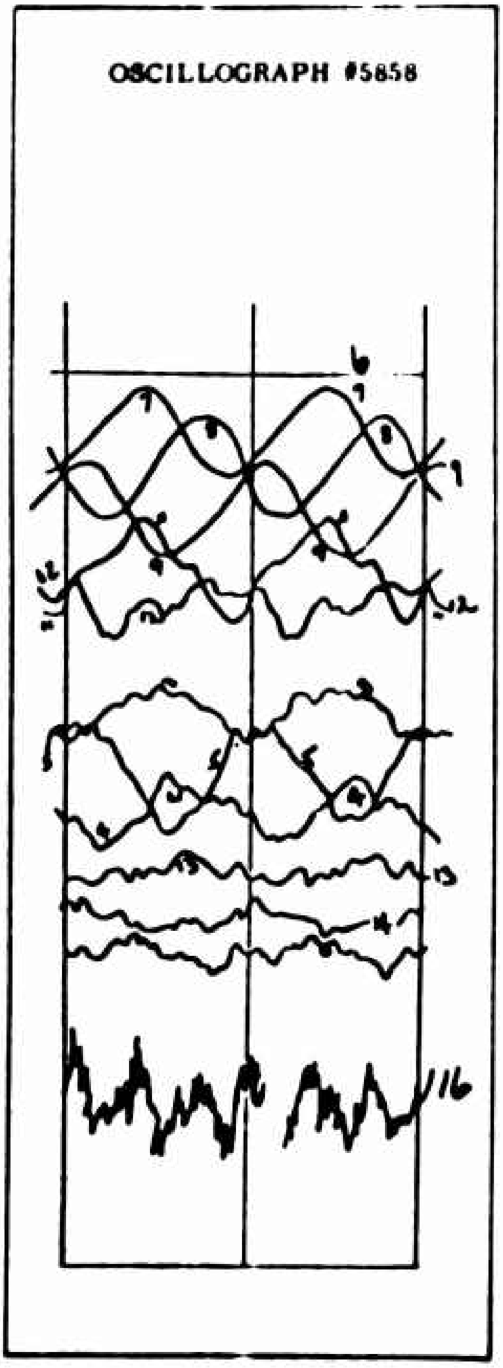
TABLE 21.4a CONFIGURATION L

n = .60 V_{M_F} = 75.34 MPH ITEM	#5858 & #7858 OSCILLOGRAPH RECORD					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link	1-3	3.16	2.88	3.02	.28	- 287.3	28.6	lb	
#2 - Drag Link	1-4	2.68	2.28	2.48	.40	- 324.8	43.3	lb	
#3 - Drag Link	1-5	2.96	2.37	2.67	.59	- 290.1	63.2	lb	
#1 - Inbd. Flap	1-10								
#2 - Inbd. Flap	1-11	4.12	3.52	3.82	.60	+ 615.4	636.6	in-lb	
#3 - Inbd. Flap	1-12	3.74	3.43	3.59	.31	+ 615.4	328.9	in-lb	
#1 - Pitch Link	1-13	2.27	2.06	2.17	.21	+ 8.73	36.7	lb	
#2 - Pitch Link	1-14	2.00	1.84	1.92	.16	0	27.9	lb	
#3 - Pitch Link	1-15	1.81	1.60	1.71	.21	- 10.5	36.7	lb	
#1 - Mid Chord	2-6	2.68	2.39	2.54	.29	-3440.2	597.4	in-lb	
#1 - Mid Flap	2-8	4.38	3.62	4.00	.76	+ 217.3	323.8	in-lb	
#1 - Mid Torsion	2-10	3.02	2.97	3.00	.05	+ 70.9	59.1	in-lb	
#1 - Outbd. Flap	2-12	3.54	1.66	2.60	1.88	+ 45.2	293.3	in-lb	
Model Attitude	2-11	1.83	1.83	1.83	0	- 4.69		deg	
Collective Pitch	2-13	2.48	2.46	2.47	.02	+ 3.38		deg	
#1 - Cyclic Pitch	1-7	4.81	4.34	4.58	.47	+ 2.66		deg	
#2 - Cyclic Pitch	1-8	4.65	4.11	4.38	.54	+ 3.65		deg	
#3 - Cyclic Pitch	1-9	4.41	3.88	4.15	.53	+ 1.82		deg	
Gyro Roll Pos.	2-3	5.79	5.39	5.59	.40	+ 2.04		deg	
Gyro Pitch Pos.	2-5	4.43	4.26	4.35	.17	- 1.89		deg	
Thrust	2-17	1.21	1.18	1.20	.03	+ 169.9		lb	
Drag	2-15	1.16	1.16	1.16	0	+ .51		lb	
Roll Moment	2-7	3.84	3.83	3.84	.01			lb	
Pitch Moment	2-9	3.15	3.14	3.15	.01			lb	
Lat. Vibration	2-14	1.70	1.46	1.58	.24		.65	$\frac{ft/sec^2}{G}$	
Long. Vibration	2-16	1.66	.86	1.26	.80		2.00		
Vert. Vibration	1-16	1.30	.59	.95	.71		1.78		

TABLE 21.4b CONFIGURATION L

$n = .60$

$V_{M_F} = 75.34$ MPH



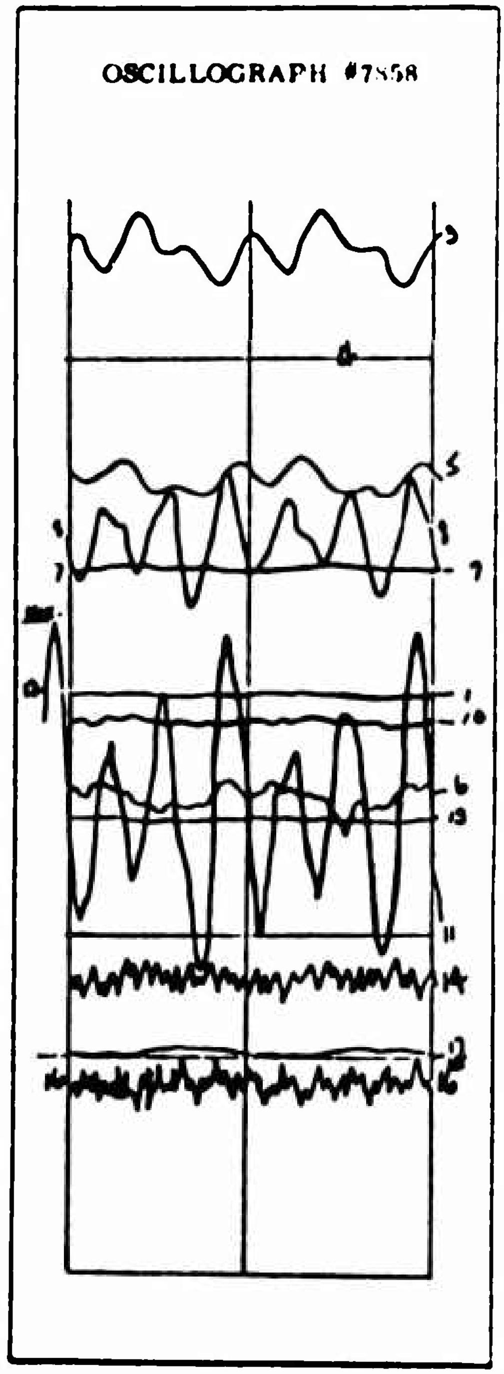


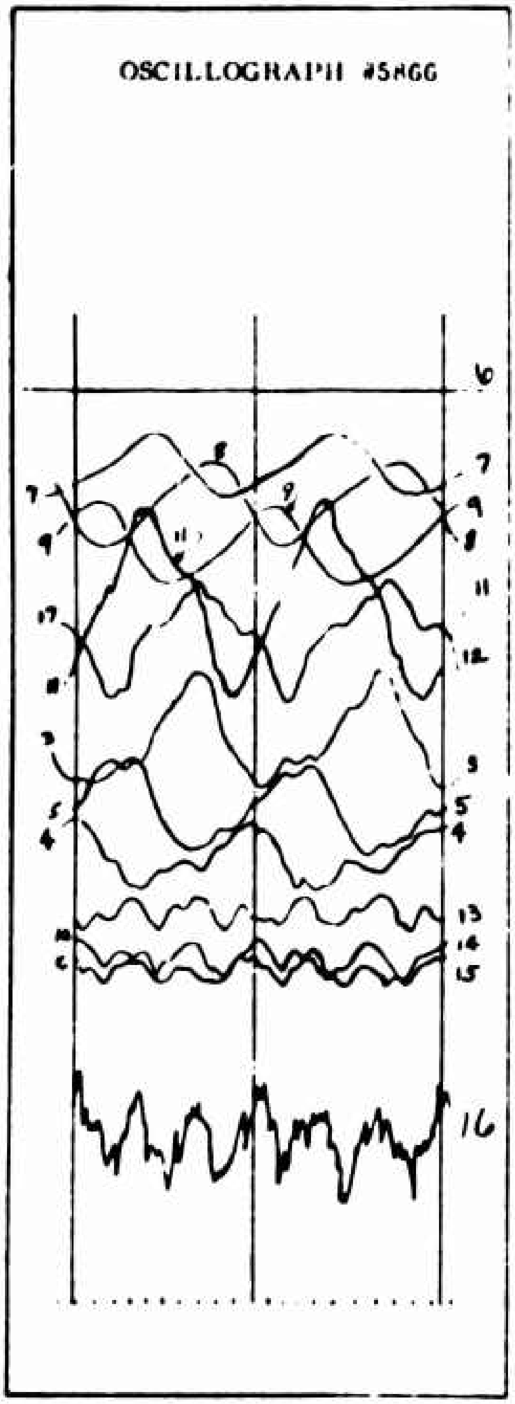
TABLE 21.5a CONFIGURATION L

n = .47 V_{M_F} = 100.70 MPH ITEM	#5866 & #7866 OSCILLOGRAPH RECORD TR. No.	MAX	MIN	AVE	2A	REDUCED DATA AVE	2A	UNITS	CYC REV.
#1 - Drag Link	1-3	3.39	2.76	3.08	.63	- 281.1	64.4	lb	
#2 - Drag Link	1-4	2.57	2.21	3.39	.36	- 334.5	39.0	lb	
#3 - Drag Link	1-5	2.88	2.40	2.64	.48	- 293.3	51.4	lb	
#1 - Inbd. Flap	1-10								
#2 - Inbd. Flap	1-11	4.30	3.25	3.77	1.03	+ 562.3	1092.8	in-lb	
#3 - Inbd. Flap	1-12	3.87	3.23	3.55	.64	+ 572.9	679.0	in-lb	
#1 - Pitch Link	1-13	2.19	2.01	2.10	.18	- 3.49	31.4	lb	
#2 - Pitch Link	1-14	2.15	1.74	1.95	.41	+ 5.24	71.6	lb	
#3 - Pitch Link	1-15	1.87	1.70	1.79	.17	+ 3.49	29.7	lb	
#1 - Mid Chord	2-6	2.65	2.48	2.57	.17	-3378.4	350.2	in-lb	
#1 - Mid Flap	2-8	4.44	3.62	4.03	.82	+ 230.0	349.3	in-lb	
#1 - Mid Torsion	2-10	3.05	2.96	3.01	.09	+ 82.7	106.4	in-lb	
#1 - Outbd. Flap	2-12	3.83	1.68	2.76	2.15	+ 70.2	335.4	in-lb	
Model Attitude	2-11	1.95	1.95	1.95	0	- 3.89		deg	
Collective Pitch	2-13	2.10	2.07	2.09	.03	+ 1.52		deg	
#1 - Cyclic Pitch	1-7	4.66	4.32	4.49	.34	+ 1.40		deg	
#2 - Cyclic Pitch	1-8	4.51	4.05	4.28	.46	+ 2.39		deg	
#3 - Cyclic Pitch	1-9	4.28	3.85	4.07	.43	+ .61		deg	
Gyro Roll Pos.	2-3	5.76	5.17	5.49	.61	+ 1.69		deg	
Gyro Pitch Pos.	2-5	4.62	4.33	4.48	.29	- 1.21		deg	
Thrust	2-17	1.02	.97	1.00	.05	+ 111.3		lb	
Drag	2-15	3.72	3.63	3.68	.09	+ 64.5		lb	
Roll Moment	2-7	3.77	3.75	3.76	.02			lb	
Pitch Moment	2-9	3.13	3.13	3.13	0			lb	
Lat. Vibration	2-14	1.76	1.45	1.61	.31	.837		$\frac{ft/sec^2}{G}$	
Long. Vibration	2-16	1.19	.86	1.03	.33	.825			
Vert. Vibration	1-16	1.26	.53	.90	.73	1.825			

TABLE 21.5b CONFIGURATION L

$n = 1.03$

$V_{M_F} = 52.08$ MPH



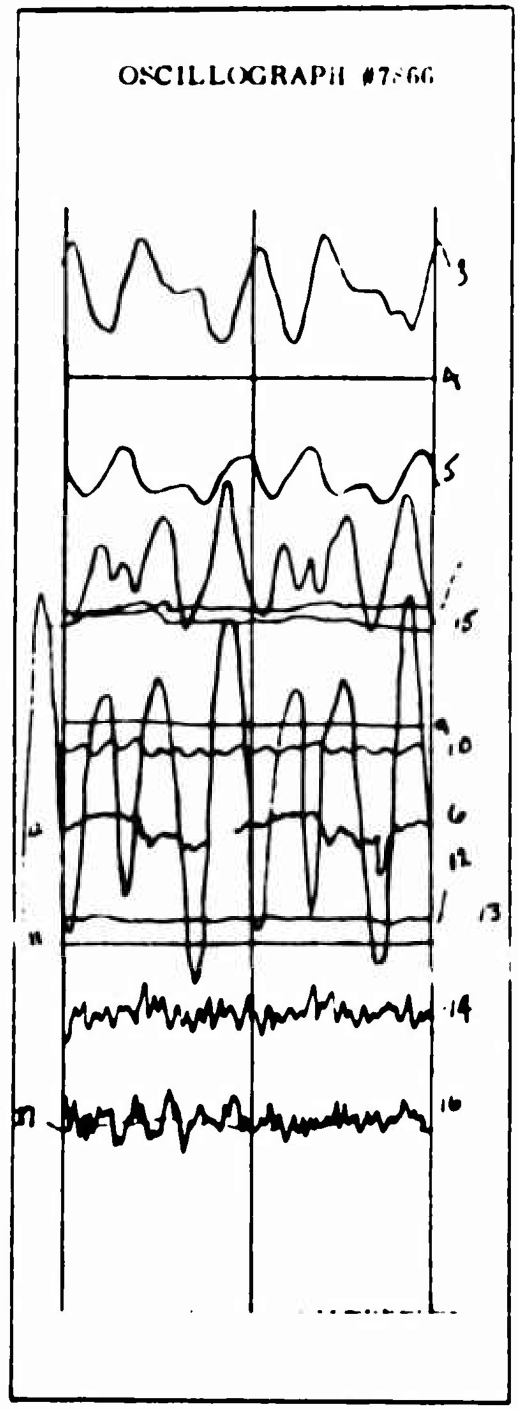


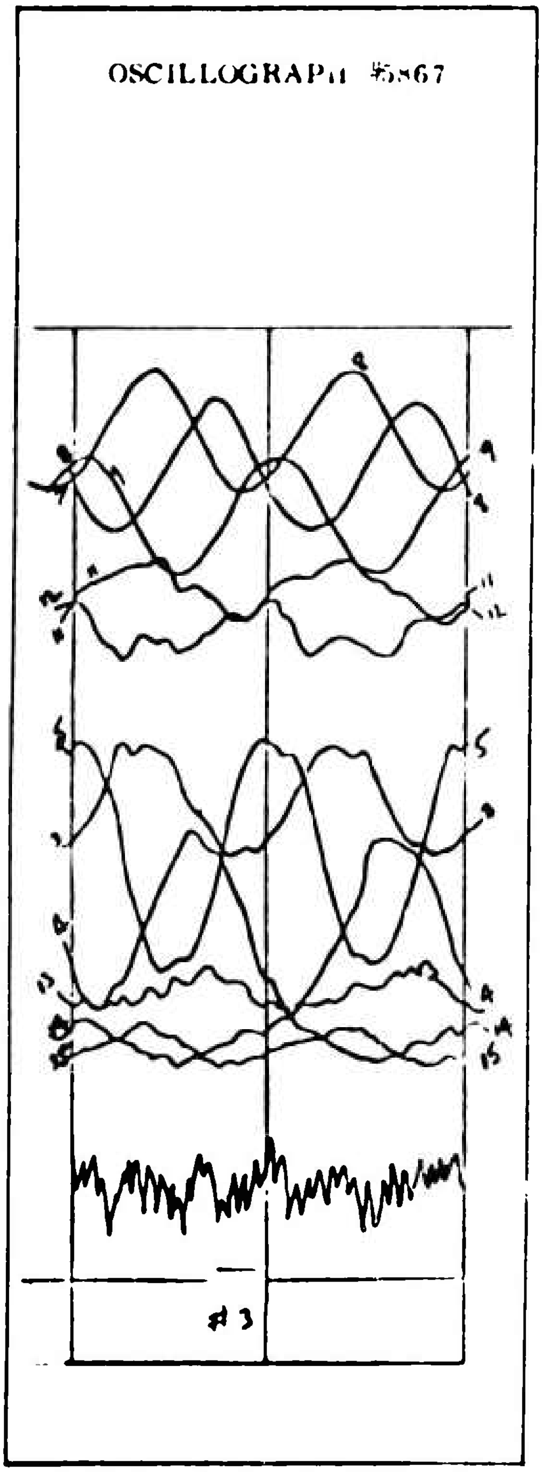
TABLE 21.6a CONFIGURATION L

n = 1.03 V_{M_F} = 52.08 MPH ITEM	#5867 & #7867 OSCILLOGRAPH RECORD TR. No.	MAX	MIN	AVE	2A	REDUCED DATA AVE	2A	UNITS	CYC REV.
#1 - Drag Link	1-3	3.13	2.57	2.85	.56	- 304.7	57.3	lb	
#2 - Drag Link	1-4	2.70	1.77	2.24	.93	- 350.7	60.6	lb	
#3 - Drag Link	1-5	3.15	2.01	2.58	1.14	- 229.7	122.0	lb	
#1 - Inbd. Flap	1-10								
#2 - Inbd. Flap	1-11	4.07	3.77	3.92	.30	+ 721.5	318.3	in-lb	
#3 - Inbd. Flap	1-12	3.88	3.58	3.73	.30	+ 763.9	318.3	in-lb	
#1 - Pitch Link	1-13	2.03	1.82	1.93	.21	- 33.2	36.7	lb	
#2 - Pitch Link	1-14	1.76	1.51	1.64	.26	- 48.9	45.4	lb	
#3 - Pitch Link	1-15	1.74	1.52	1.63	.22	- 24.5	38.4	lb	
#1 - Mid Chord	2-6	2.66	2.47	2.57	.19	-3378.4	391.4	in-lb	
#1 - Mid Flap	2-8	4.30	3.87	4.08	.43	+ 251.3	183.2	in-lb	
#1 - Mid Torsion	2-10	3.01	2.95	2.98	.06	+ 47.3	70.9	in-lb	
#1 - Outbd. Flap	2-12	3.26	1.86	2.56	1.40	- 62.4	218.4	in-lb	
Model Attitude	2-11	1.54	1.54	1.54	0	- 6.63		deg	
Collective Pitch	2-13	3.13	3.12	3.13	.01	+ 6.57		deg	
#1 - Cyclic Pitch	1-7	5.04	4.43	4.74	.61	+ 4.90		deg	
#2 - Cyclic Pitch	1-8	4.89	4.21	4.55	.68	+ 5.80		deg	
#3 - Cyclic Pitch	1-9	4.61	3.99	4.30	.62	+ 4.10		deg	
Gyro Roll Pos.	2-3	5.78	5.51	5.65	.27	+ 2.24		deg	
Gyro Pitch Pos.	2-5	4.32	4.16	4.24	.16	- 2.46		deg	
Thrust	2-17	1.75	1.73	1.74	.02	+ 328.2		lb	
Drag	2-15	1.11	1.11	1.11	0	- .76		lb	
Roll Moment	2-7	3.75	3.74	3.75	.01			lb	
Pitch Moment	2-9	3.14	3.14	3.14	0			lb	
Lat. Vibration	2-14	1.70	1.50	1.60	.20		.54	$\frac{ft/sec^2}{G}$	
Long. Vibration	2-16	1.13	.93	1.03	.20		.50		
Vert. Vibration	1-16	1.16	.62	.89	.54		1.35		

TABLE 21.6b CONFIGURATION L

n = 1.03

V_{M_F} = 52.08 MPH



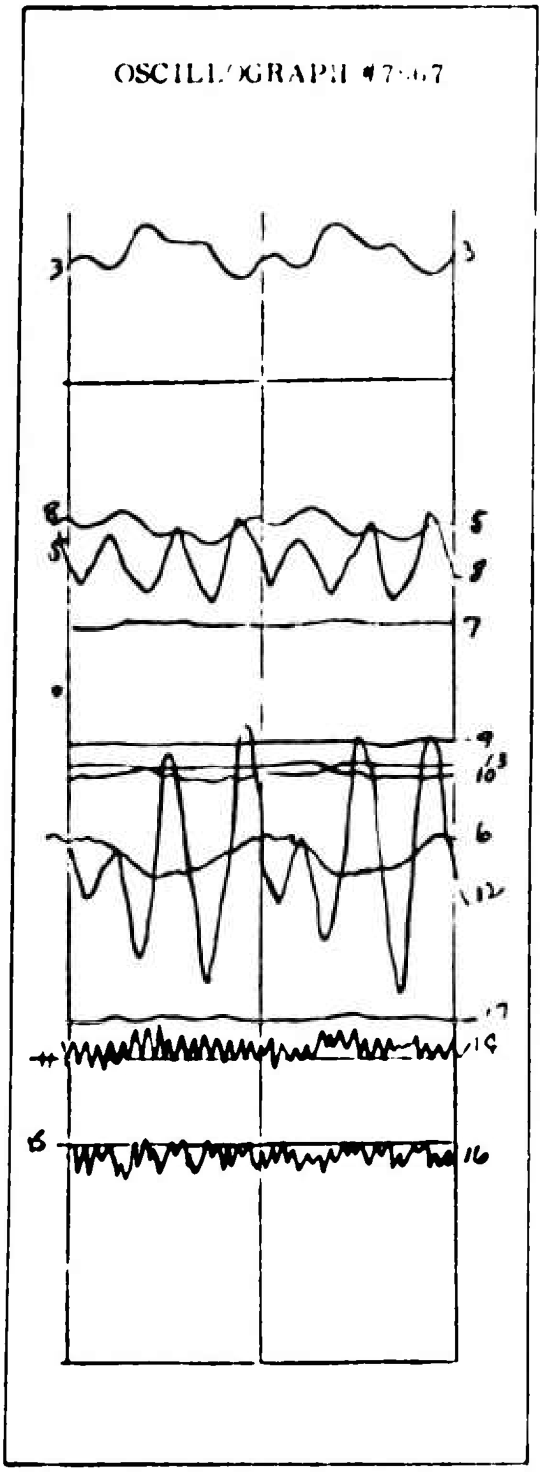


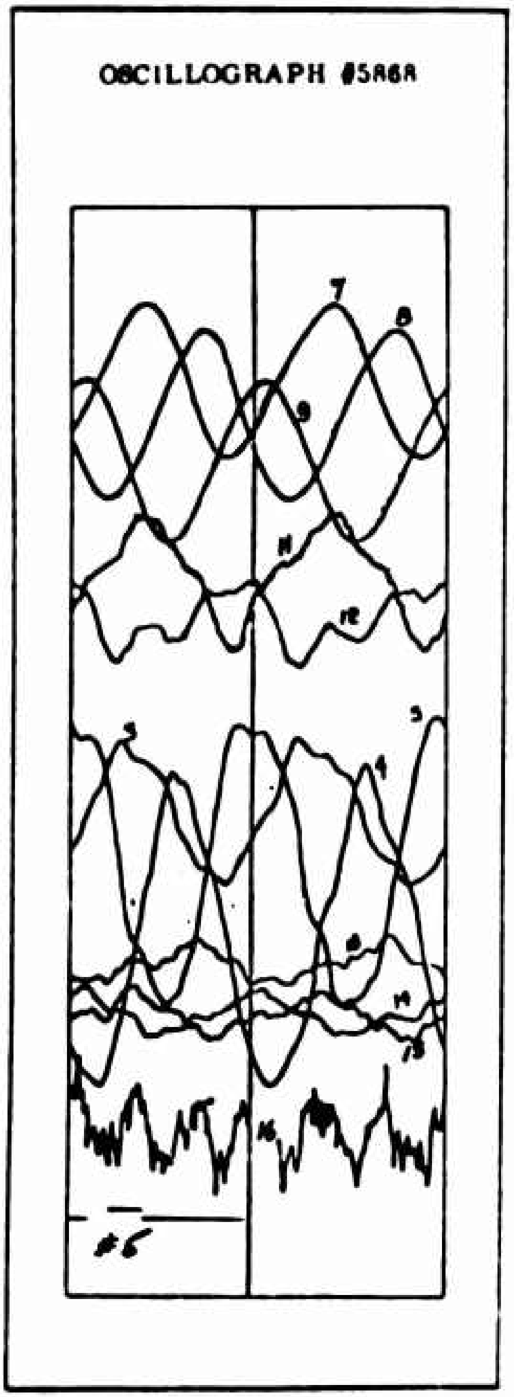
TABLE 21. a CONFIGURATION L

n = 1.01 V_{M_F} = 67.55 MPH ITEM	#[illegible] & #7868 OSCILLOGRAPH RECORD					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link	1-3	3.03	2.22	2.63	.81	-327.2	82.8	lb	
#2 - Drag Link	1-4	2.87	1.14	2.01	1.73	-375.6	87.7	lb	
#3 - Drag Link	1-5	3.13	1.58	2.35	1.55	-324.4	165.9	lb	
#1 - Inbd. Flap	1-10								
#2 - Inbd. Flap	1-11	4.24	3.49	3.87	.75	+668.4	795.8	in-lb	
#3 - Inbd. Flap	1-12	3.86	3.40	3.63	.46	+657.8	468.1	in-lb	
#1 - Pitch Link	1-13	1.96	1.70	1.83	.26	- 50.6	45.4	lb	
#2 - Pitch Link	1-14	1.67	1.40	1.53	.27	- 68.1	47.2	lb	
#3 - Pitch Link	1-15	1.68	1.39	1.53	.29	- 41.9	50.6	lb	
#1 - Mid Chord	2-6	2.71	2.37	2.54	.34	-3440.2	700.4	in-lb	
#1 - Mid Flap	2-8	4.47	3.70	4.09	.77	+255.6	328.0	in-lb	
#1 - Mid Torsion	2-10	3.00	2.93	2.97	.07	+ 35.5	82.7	in-lb	
#1 - Outbd. Flap	2-12	3.84	1.61	2.73	2.23	+ 65.5	347.9	in-lb	
Model Attitude	2-11	1.03	1.03	1.03	0	- 10.05		deg	
Collective Pitch	2-13	3.59	3.58	3.59	.01	+ 8.84		deg	
#1 - Cyclic Pitch	1-7	5.35	4.53	4.94	.82	+ 7.70		deg	
#2 - Cyclic Pitch	1-8	5.22	4.31	4.76	.91	+ 8.44		deg	
#3 - Cyclic Pitch	1-9	4.94	4.07	4.51	37	+ 7.30		deg	
Gyro Roll Pos.	2-3	6.18	5.75	5.97	.43	+ 3.35		deg	
Gyro Pitch Pos.	2-5	4.20	3.98	4.09	.22	- 3.25		deg	
Thrust	2-17	1.71	1.69	1.70	.03	+316.4		lb	
Drag	2-15	1.11	1.11	1.11	0	- .76		lb	
Roll Moment	2-7	3.77	3.74	3.76	.03			lb	
Pitch Moment	2-9	3.19	3.16	3.18	.03			lb	
Lat. Vibration	2-14	1.70	1.44	1.57	.26		.70	$\frac{ft/sec^2}{G}$	
Long. Vibration	2-16	1.23	.89	1.06	.34		.85		
Vert. Vibration	1-16	1.29	.54	.92	.75		1.875		

TABLE 21.7b CONFIGURATION L

$n = 1.01$

$V_{M_F} = 67.55$ MPH



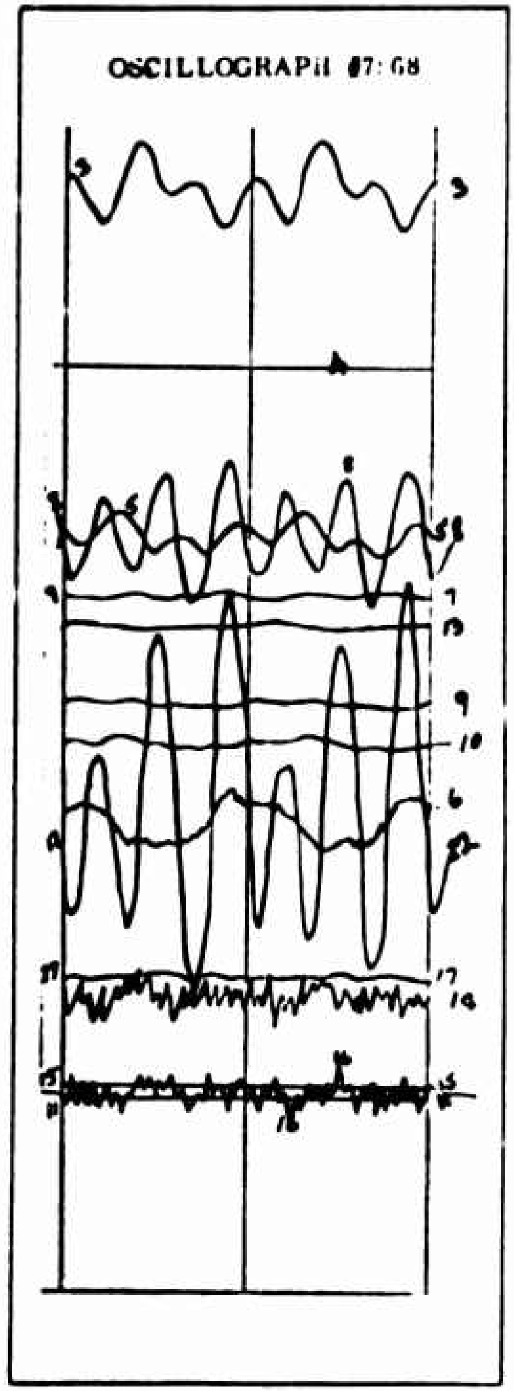


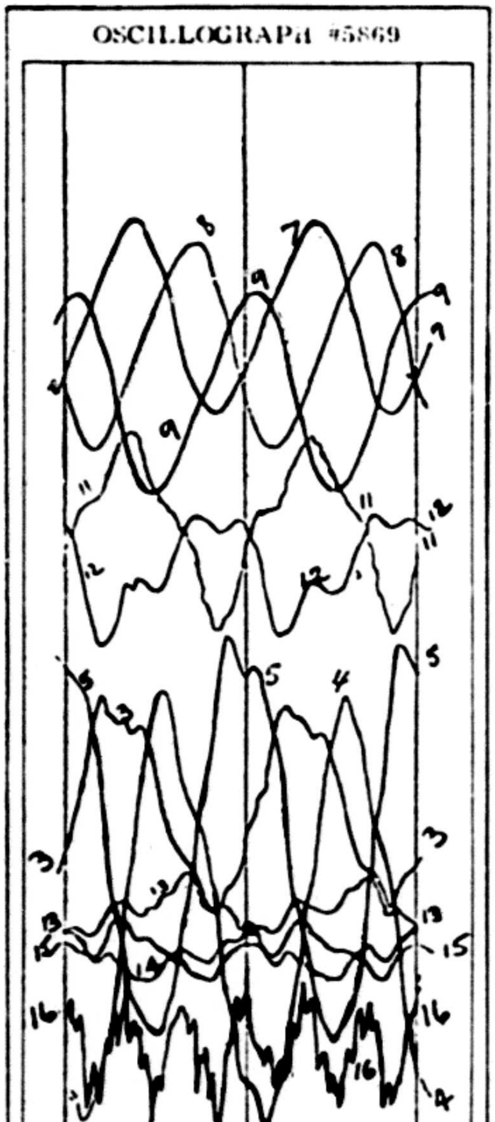
TABLE 21.6a CONFIGURATION L

n = 1.04 V_{M_F} = 76.42 MPH ITEM	#5869 & #7869 OSCILLOGRAPH RECORD					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link	1-3	2.91	1.70	2.31	1.21	-337.4	123.7	lb	
#2 - Drag Link	1-4	2.96	.48	1.72	2.48	-407.0	268.5	lb	
#3 - Drag Link	1-5	3.23	.93	2.08	2.30	-353.2	246.2	lb	
#1 - Inbd. Flap	1-10								
#2 - Inbd. Flap	1-11	4.44	3.27	3.85	1.17	+647.2	1241.4	in-lb	
#3 - Inbd. Flap	1-12	3.94	3.21	3.57	.73	+594.2	774.5	in-lb	
#1 - Pitch Link	1-13	1.90	1.57	1.74	.33	- 66.4	57.6	lb	
#2 - Pitch Link	1-14	1.58	1.30	1.44	.28	- 83.8	48.9	lb	
#3 - Pitch Link	1-15	1.64	1.30	1.47	.34	- 52.4	59.4	lb	
#1 - Mid Chord	2-6	2.72	2.30	2.51	.42	-3502	865.2	in-lb	
#1 - Mid Flap	2-8	4.73	3.52	4.13	1.21	+272.6	515.5	in-lb	
#1 - Mid Torsion	2-10	3.00	2.91	2.96	.09	+ 23.6	106.4	in-lb	
#1 - Outbd. Flap	2-12	4.50	1.10	2.80	3.40	+ 76.4	530.4	in-lb	
Model Attitude	2-11	.88	.87	.88	.01	- 11.09		deg	
Collective Pitch	2-13	4.07	4.05	4.06	.02	+ 11.17		deg	
#1 - Cyclic Pitch	1-7	5.66	4.54	5.10	1.12	+ 9.94		deg	
#2 - Cyclic Pitch	1-8	5.53	4.35	4.94	1.18	+ 10.71		deg	
#3 - Cyclic Pitch	1-9	5.25	4.11	4.68	1.14	+ 9.88		deg	
Gyro Roll Pos.	2-3	6.46	5.95	6.21	.51	+ 4.17		deg	
Gyro Pitch Pos.	2-5	4.02	3.72	3.87	.30	- 4.40		deg	
Thrust	2-17	1.82	1.77	1.80	.05	+345.7		lb	
Drag	2-15	1.10	1.10	1.10	0	- 1.02		lb	
Roll Moment	2-7	3.72	3.70	3.71	.02			lb	
Pitch Moment	2-9	3.27	3.23	3.25	.04			lb	
Lat. Vibration	2-14	1.76	1.45	1.61	.31		.84	$\frac{ft/sec^2}{g}$	
Long. Vibration	2-16	1.28	.89	1.08	.39		.975		
Vert. Vibration	1.16	1.34	.40	.87	.94		2.35		

TABLE 21.8b CONFIGURATION L

n = 1.04

V_{M_F} = 76.42 MPH



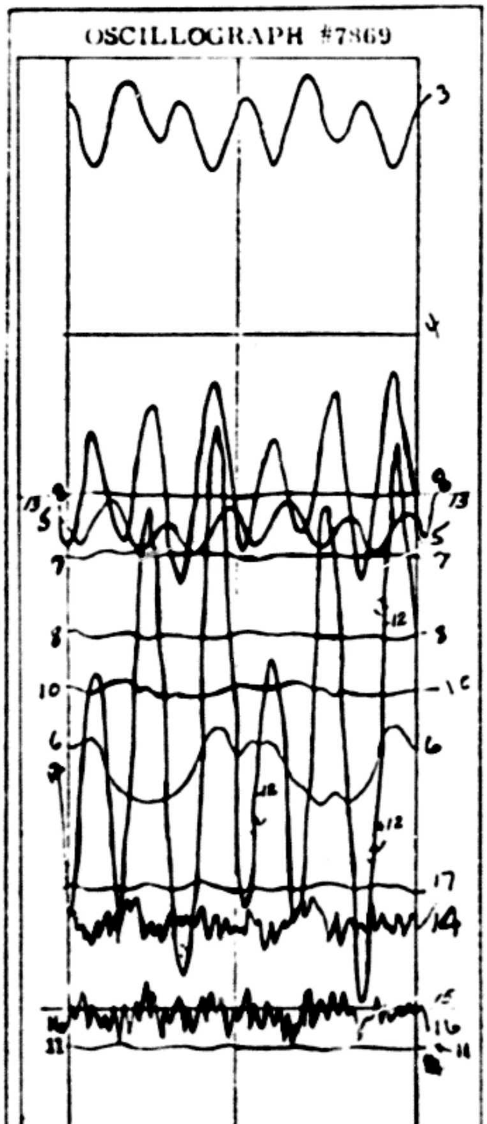


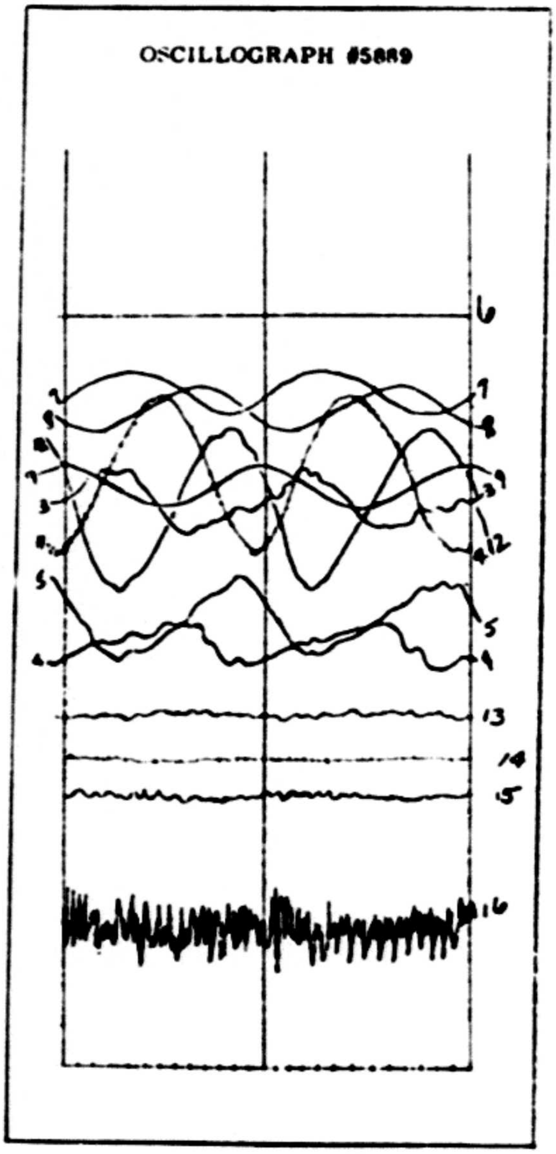
TABLE 22.1a CONFIGURATION M

n = .58 V_{M_F} = 40.06 MPH (Ω = 460 RPM) ITEM	#5889 & #7889 OSCILLOGRAPH RECORD					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link	1-3	3.90	3.48	3.69	.42	-214.7	42.9		
#2 - Drag Link	1-4	2.89	2.59	2.74	.30	-297.7	32.5	lb	
#3 - Drag Link	1-5	3.21	2.67	2.94	.54	-234.4	57.8	lb	
#1 - Inbd. Flap	1-10								
#2 - Inbd. Flap	1-11	4.38	3.34	3.86	1.04	+657.8	1103.0	in-lb	
#3 - Inbd. Flap	1-12	4.18	3.12	3.65	1.06	+689.7	1124.7	in-lb	
#1 - Pitch Link	1-13	2.32	2.27	3.30	.05	+178.1	8.73	lb	
#2 - Pitch Link	1-14	2.00	2.00	2.00	0	- 3.49	0	lb	
#3 - Pitch Link	1-15	1.81	1.74	1.78	.07	+ 6.99	12.2	lb	
#1 - Mid Chord	2-6	2.96	2.80	2.88	.16	-2534	329.6	in-lb	
#1 - Mid Flap	2-8	4.27	3.73	4.00	.54	+119.3	230.0	in-lb	
#1 - Mid Torsion	2-10	2.93	2.89	2.91	.04	-271.9	43.3	in-lb	
#1 - Outbd. Flap	2-12	2.84	2.22	2.53	.62	+ 46.8	06.7	in-lb	
Model Attitude	2-11	2.44	2.44	2.44	0	- .40		deg	
Collective Pitch	2-13	2.11	2.10	2.11	.01	+ .69			
#1 - Cyclic Pitch	1-7	4.54	4.27	4.41	.27	- .42		deg	
#2 - Cyclic Pitch	1-8	4.45	4.15	4.30	.30	+ 3.02		deg	
#3 - Cyclic Pitch	1-9	3.92	3.65	3.79	.27	+ 1.06		deg	
Gyro Roll Pos.	2-3	5.68	5.50	5.59	.18	+ 1.59		deg	
Gyro Pitch Pos.	2-5	4.37	4.27	4.32	.10	- 2.52		deg	
Thrust	2-17	.88	.80	.84	.08	168.3		lb	
Drag	2-15	1.57	1.47	1.52	.10	+ 5.08		lb	
Roll Moment	2-7	3.17	3.17	3.17	0			lb	
Pitch Moment	2-9	3.97	3.91	3.94	.06			lb	
Lat. Vibration	2-14	1.81	1.48	1.65	.33		.89	$\frac{ft/sec^2}{G}$	
Long. Vibration	2-16	1.29	.81	1.05	.48		1.20		
Vert. Vibration	1-16	1.21	.61	.91	.60		1.50		

TABLE 22.1b CONFIGURATION M

η = .58

V_{M_F} = 40.06 MPH



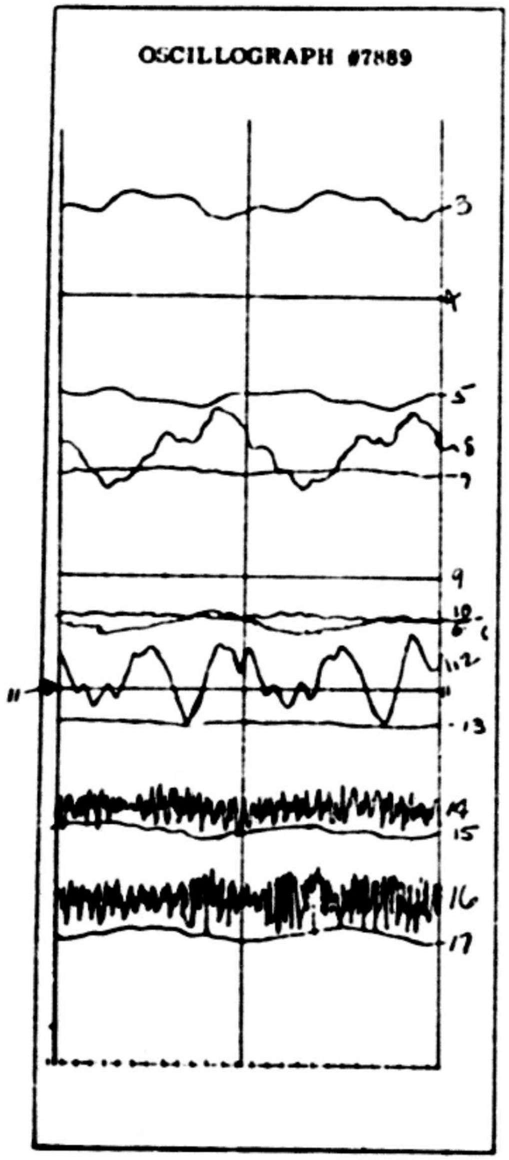


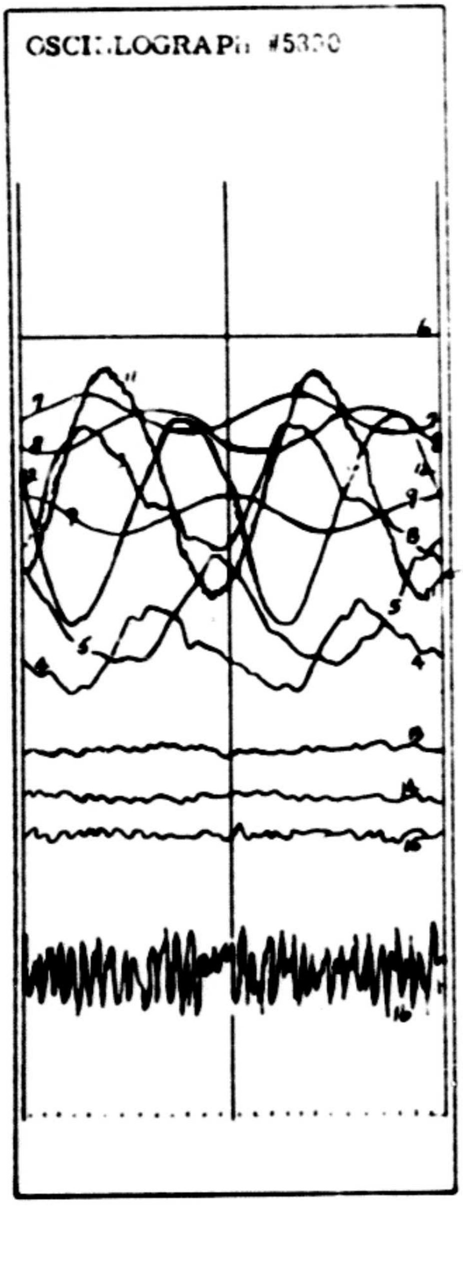
TABLE 22.2a CONFIGURATION M

n = .867 V_{M_T} = 42.08 MPH (Ω = 460 RPM) ITEM	#589C & #789 OSCILLOGRAPH RECORD					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link	1-3	4.34	3.52	3.93	.82	-212.7	83.8		
#2 - Drag Link	1-4	3.24	2.66	2.95	.58	-275.0	62.8	lb	
#3 - Drag Link	1-5	3.54	2.86	3.20	.68	-206.7	72.8		
#1 - Inbd. Flap	1-10								
#2 - Inbd. Flap	1-11	4.68	3.2[illegible]	3.97	1.42	763.9	1506.6	in-lb	
#3 - Inbd. Flap	1-12	4.41	3.[illegible]9	3.75	1.32	806.4	1400.5		
#1 - Pitch Link	1-13	2.34	2.26	2.30	.08	- 5.24	14.0		
#2 - Pitch Link	1-14	2.03	1.96	2.00	.07	- 6.99	12.2	lb	
#3 - Pitch Link	1-15	1.82	1.72	1.77	.10	6.99	17.5		
#1 - Mid Chord	2-6	2.97	2.81	2.8[illegible]	.16	-2369	329.6		
#1 - Mid Flap	2-8	4.32	3.69	4.01	.63	230	268.4		
#1 - Mid Torsion	2-10	2.91	2.87	2.89	.04	23.6	47.3	in-lb	
#1 - Outbd. Flap	2-12	2.74	2.04	2.39	.70	20.3	109.2		
Model Attitude	2-11	3.05	3.05	3.05	0	3.55			
Collective Pitch	2-13	2.22	2.20	2.21	.02	1.18			
#1 - Cyclic Pitch	1-7	4.52	4.27	4.40	.25	.14		deg	
#2 - Cyclic Pitch	1-8	4.44	4.15	4.30	.29	3.02			
#3 - Cyclic Pitch	1-9	3.89	3.67	3.78	.22	.61			
Gyro Roll Pos.	2-3	5.68	5.39	5.54	.29	2.00			
Gyro Pitch Pos.	2-5	4.39	4.25	4.32	.14	1.52		deg	
Thrust	2-17	.99	.96	.98	.03	271.6			
Drag	2-15	4.27	4.19	4.23	.08	73.4			
Roll Moment	2-7	3.85	3.81	3.83	.04			lb	
Pitch Moment	2-9	3.10	3.10	3.10	0				
Lat. Vibration	2-14	1.79	1.53	1.66	.26		.702		
Long. Vibration	2-16	1.29	.76	1.03	.53		1.325	$\frac{ft/sec^2}{g}$	
Vert. Vibration	1-16	1.23	.60	.92	.63		1.575		

TABLE 22.2b CONFIGURATION M

$n = .87$

$V_{M_F} = 42.08$ MPH



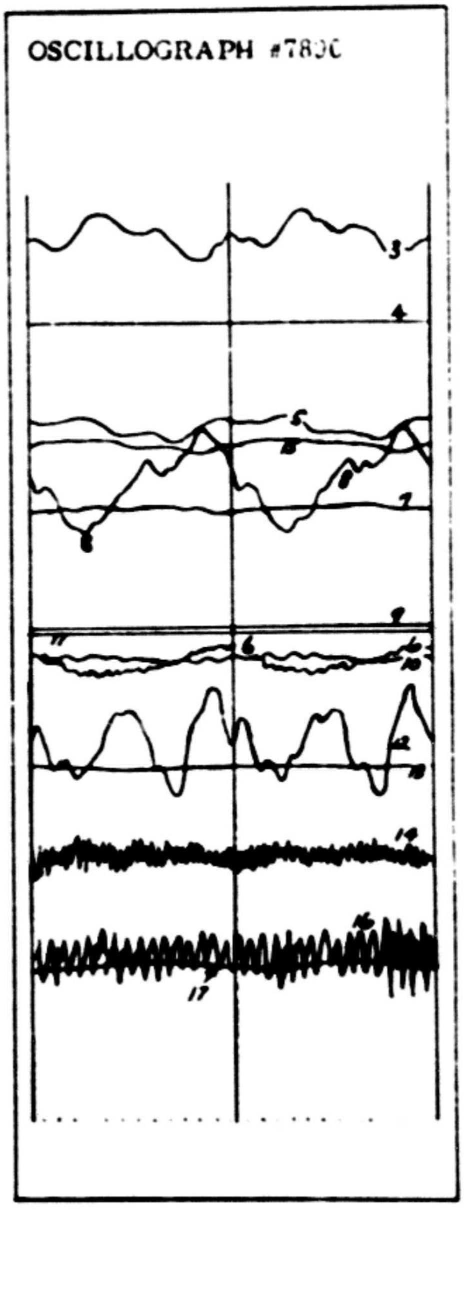


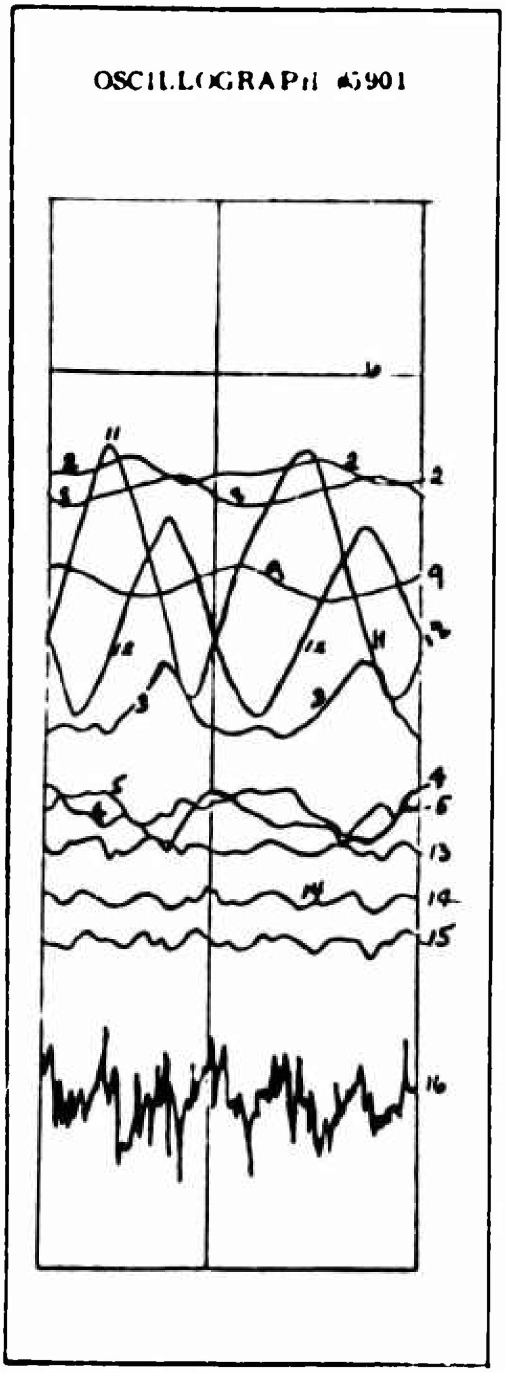
TABLE 22.3a CONFIGURATION M

n = .52 V_{M_T} = 82.63 MPH ITEM	#5901 & #7901 OSCILLOGRAPH RECORD					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link #2 - Drag Link #3 - Drag Link	1-3 1-4 1-5	3.35 2.62 2.62	2.91 2.28 2.37	3.13 2.45 2.49	.44 .34 .25	-272.0 -329.1 -282.6	45.0 36.8 26.8	lb lb lb	
#1 - Inbd. Flap #2 - Inbd. Flap #3 - Inbd. Flap	1-10 1-11 1-12	 4.50 4.11	 3.11 3.02	 3.81 3.56	 1.39 1.09	 +604.8 +594.2	 1474.8 1156.5	 in-lb in-lb	
#1 - Pitch Link #2 - Pitch Link #3 - Pitch Link	1-13 1-14 1-15	2.38 2.09 1.87	2.23 1.95 1.72	2.31 2.02 1.80	.15 .14 .15	+5.24 0 +10.5	26.2 24.5 26.2	lb lb lb	
#1 - Mid Chord #1 - Mid Flap #1 - Mid Torsion #1 - Outbd. Flap	2-6 2-8 2-10 2-12	2.47 4.38 2.96 3.48	2.35 3.62 2.91 1.71	2.41 4.00 2.94 2.60	.12 .76 .05 1.77	-3502 +119.3 -236.4 +42.1	247.2 323.8 59.1 276.1	in-lb in-lb in-lb in-lb	
Model Attitude Collective Pitch #1 - Cyclic Pitch #2 - Cyclic Pitch #3 - Cyclic Pitch	2-11 2-13 1-7 1-8 1-9	2.00 2.10 2.37 4.34 3.83	2.00 2.09 2.23 4.17 3.67	2.00 2.10 2.30 4.26 3.75	0 .01 .14 .17 .16	-3.35 +.61 -30.0 +2.52 +.46		deg deg deg deg deg	
Gyro Roll Pos. Gyro Pitch Pos.	2-3 2-5	5.53 4.48	5.14 4.30	5.34 4.39	.39 .18	+.73 -2.15		deg deg	
Thrust Drag Roll Moment Pitch Moment	2-17 2-15 2-7 2-9	.86 2.61 3.72 3.16	.75 2.51 3.68 3.15	.81 2.56 3.70 3.16	.11 .10 .04 .01	145.4 +31.5		lb 'b lb lb	
Lat. Vibration Long. Vibration Vert. Vibration	2-14 2-16 1-16	1.93 1.26 1.30	1.44 .92 .49	1.69 1.09 .90	.49 .34 .81		1.32 .85 2.025	$\frac{ft/sec^2}{G}$	

TABLE 22.3b CONFIGURATION M

$n = .52$

$V_{M_F} = 82.63$ MPH



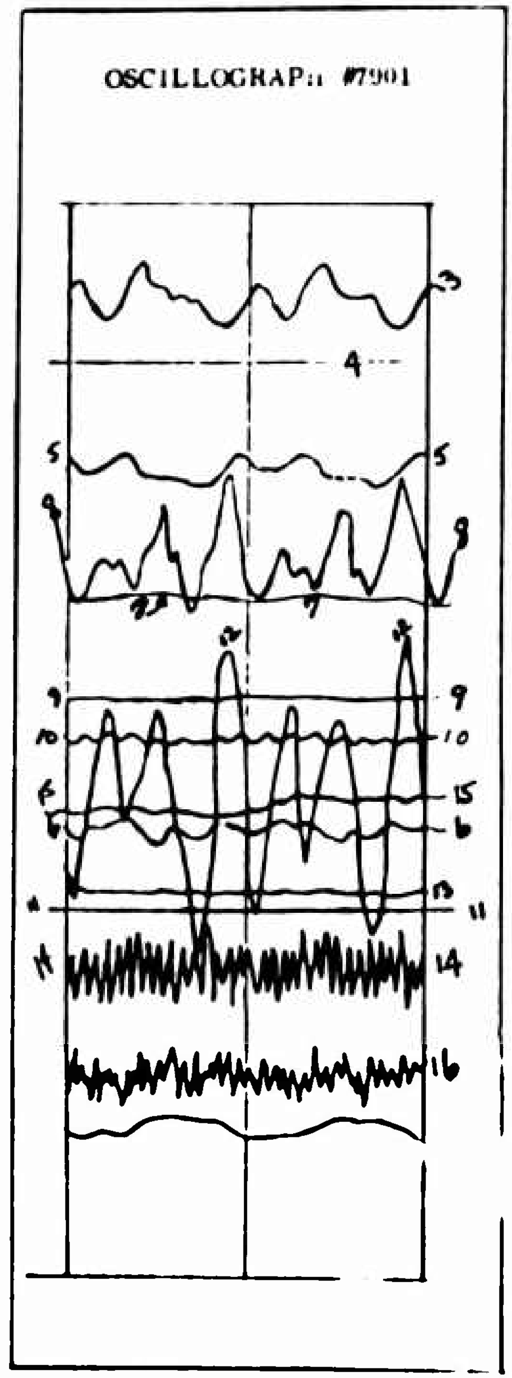


TABLE 22.4e CONFIGURATION M

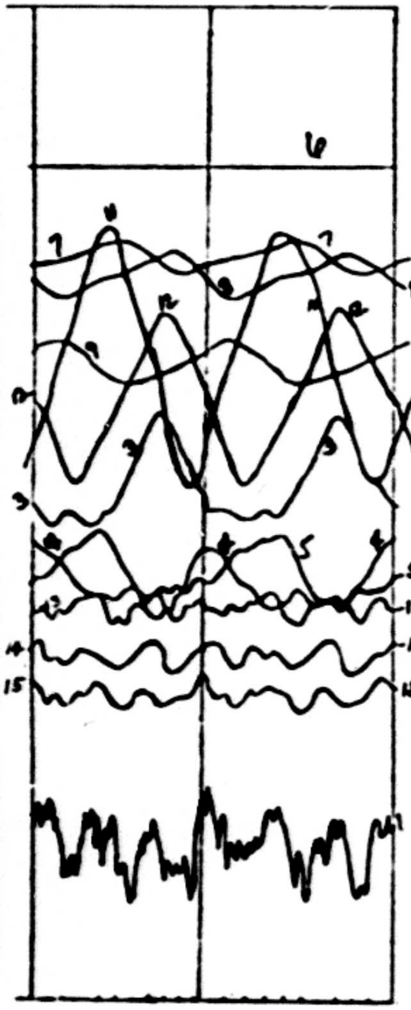
μ = .47 V_{M_T} = [illegible] MPH ITEM	[illegible] & [illegible] OSCILLOGRAPH RECORD					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link	1-3	3.44	2.79	3.12	.65	-273.0	66.5	lb	
#2 - Drag Link	1-4	2.70	2.31	2.51	.39	-322.6	42.2	lb	
#3 - Drag Link	1-5	2.77	2.35	2.56	.42	-275.1	45.0	lb	
#1 - Inbd. Flap	1-10								
#2 - Inbd. Flap	1-11	4.53	3.03	3.78	1.50	+572.9	1591.5	in-lb	
#3 - Inbd. Flap	1-12	4.08	3.04	3.56	1.04	+594.2	1103.4	in-lb	
#1 - Pitch Link	1-13	2.40	2.22	2.31	.18	+5.24	31.4	lb	
#2 - Pitch Link	1-14	2.13	1.92	2.01	.21	-1.75	36.7	lb	
#3 - Pitch Link	1-15	1.93	1.70	1.82	.23	+14.0	40.2	lb	
#1 - Mid Chord	2-6	2.50	2.23	2.37	.27	-3584.4	556.2	in-lb	
#1 - Mid Flap	2-8	4.43	3.21	3.82	1.22	+42.6	519.7	in-lb	
#1 - Mid Torsion	2-10	2.96	2.89	2.93	.07	-248.2	82.7	in-lb	
#1 - Outbd. Flap	2-12	3.65	1.73	2.69	1.92	+71.8	299.5	in-lb	
Model Attitude	2-11	2.05	2.05	2.05	0	-3.02		deg	
Collective Pitch	2-13	2.09	2.07	2.08	.02	+ .54		deg	
#1 - Cyclic Pitch	1-7	4.45	4.27	4.48	.42	+ .56		deg	
#2 - Cyclic Pitch	1-8	4.39	4.13	4.36	.26	+2.52		deg	
#3 - Cyclic Pitch	1-9	3.87	3.63	3.75	.24	+ .46		deg	
Gyro Roll Pos.	2-3	5.62	5.09	5.36	.53	+ .23		deg	
Gyro Pitch Pos.	2-5	4.48	4.23	4.36	.25	-2.31		deg	
Thrust	2-17	.88	.74	.81	.14	145.4		lb	
Drag	2-15	4.05	3.89	3.97	.16	+67.3		lb	
Roll Moment	2-7	3.69	3.66	3.68	.03			lb	
Pitch Moment	2-9	3.07	3.07	3.07	0			lb	
Lat. Vibration	2-14	1.83	1.50	1.67	.33		.89	ft/sec² / G	
Long. Vibration	2-16	1.36	.89	1.13	.47		1.18		
Vert. Vibration	1-16	1.26	.55	.91	.71		1.78		

TABLE 22.4b CONFIGURATION M

n = .47

V_{M_F} = 97.55 MPH

OSCILLOGRAPH #5902



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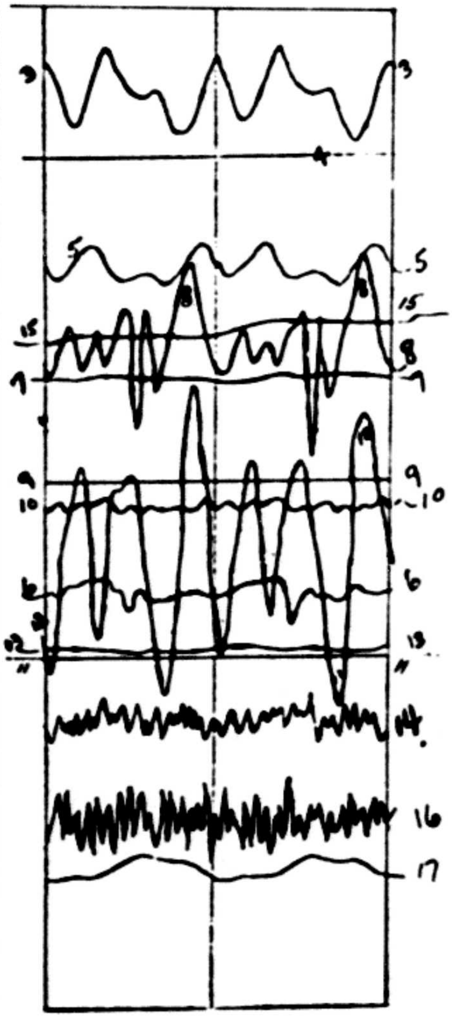


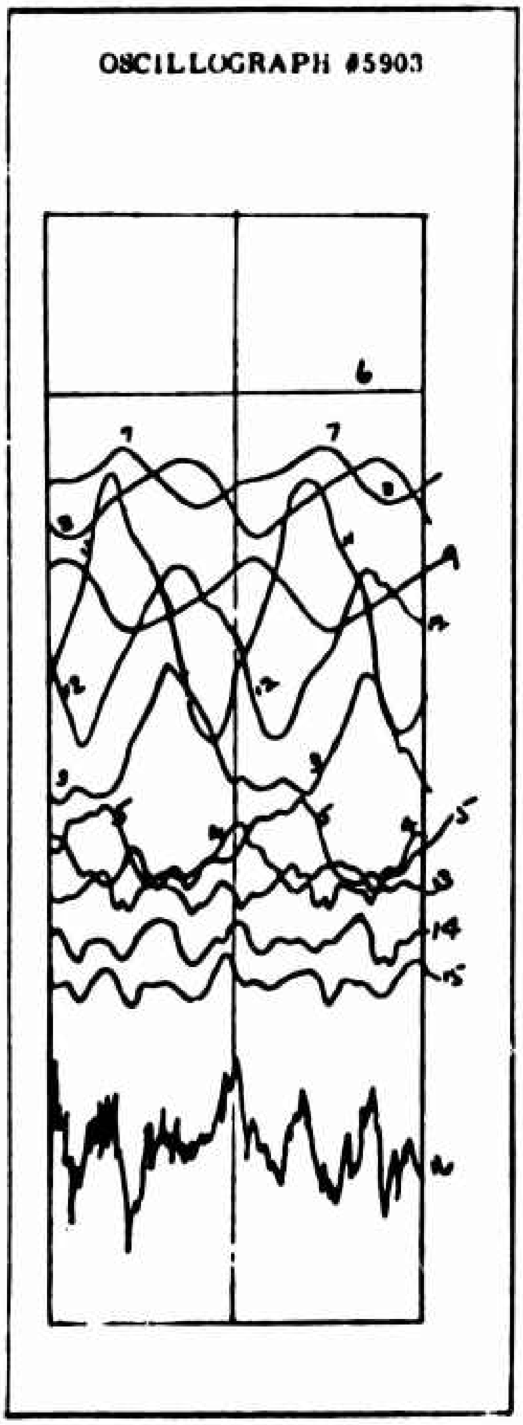
TABLE 22.5a CONFIGURATION M

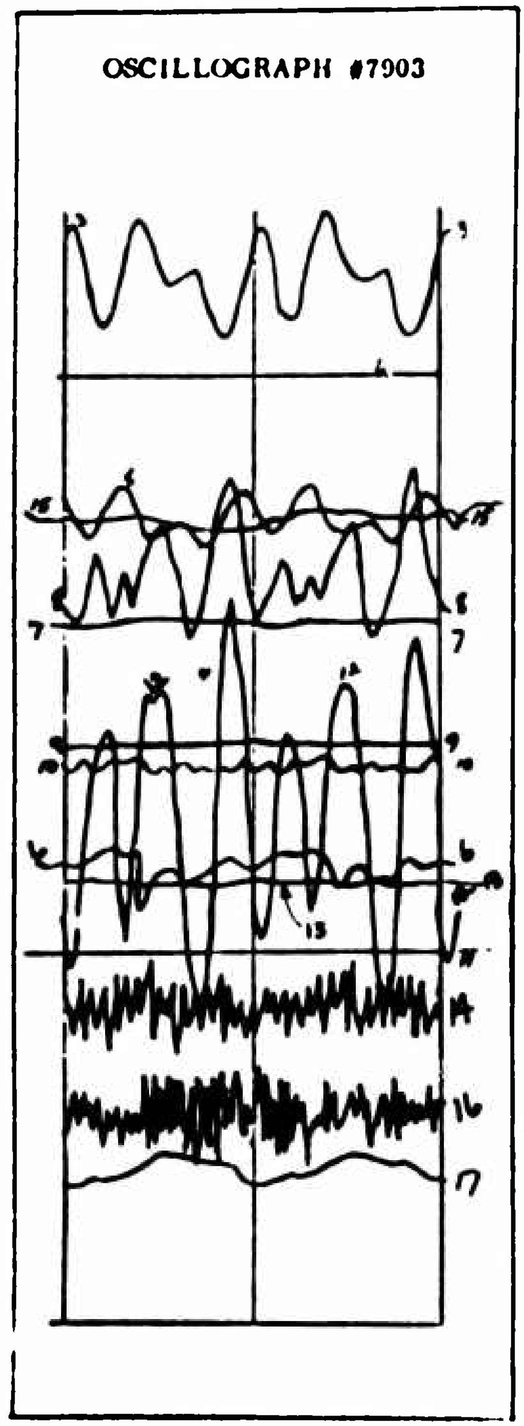
n = .46 V_{M_T} = 104.42 MPH ITEM	#5903 & #7903 OSCILLOGRAPH RECORD					REDUCED DATA			
	TR. No.	MAX	MIN	AVE	2A	AVE	2A	UNITS	CYC REV.
#1 - Drag Link	1-3	3.46	2.73	3.09	.73	-276.0	74.6	lb	
#2 - Drag Link	1-4	2.62	2.19	2.40	.43	-334.5	46.5	lb	
#3 - Drag Link	1-5	2.74	2.30	2.52	.44	-279.4	47.1	lb	
#1 - Inbd. Flap	1-10								
#2 - Inbd. Flap	1-11	4.46	3.07	3.76	1.39	+551.7	1474.8	in-lb	
#3 - Inbd. Flap	1-12	3.96	3.06	3.51	.90	+541.1	954.9	in-lb	
#1 - Pitch Link	1-13	2.39	2.18	2.29	.21	+1.75	36.7	lb	
#2 - Pitch Link	1-14	2.12	[illegible]	2.02	.23	0	40.2	lb	
#3 - Pitch Link	1-15	1.94	1.68	1.81	.26	+12.2	45.4	lb	
#1 - Mid Chord	2-6	2.49	2.19	2.34	.30	-3646.2	618.0	in-lb	
#1 - Mid Flap	2-8	[illegible]	3.62	4.06	.88	+144.8	374.9	in-lb	
#1 - Mid Torsion	2-10	[illegible]	2.89	2.94	.09	-236.4	106.4	in-lb	
#1 - Outbd. Flap	2-12	[illegible]	1.48	2.65	2.34	+48.4	365.04	in-lb	
Model Attitude	2-11	1.97	1.97	1.97	0	-3.55		deg	
Collective Pitch	2-13	2.32	2.30	2.31	.02	+1.66		deg	
#1 - Cyclic Pitch	1-7	4.59	4.28	4.43	.31	- .14		deg	
#2 - Cyclic Pitch	1-8	4.53	4.13	4.33	.40	+3.40		deg	
#3 - Cyclic Pitch	1-9	4.00	3.64	3.82	.36	+1.52		deg	
Gyro Roll Pos.	2-3	5.84	5.19	5.52	.65	+1.35		deg	
Gyro Pitch Pos.	2-5	4.40	4.10	4.25	.30	-2.88		deg	
Thrust	2-17	.88	.72	.80	.16	137.7		lb	
Drag	2-15	4.31	4.18	4.25	.13	+74.4		lb	
Roll Moment	2-7	3.71	3.67	3.69	.04			lb	
Pitch Moment	2-9	3.06	3.05	3.06	[illegible]			lb	
Lat. Vibration	2-14	1.93	1.41	1.67	.52		1.40	ft/sec² G	
Long. Vibration	2-16	1.38	.80	1.09	.58		1.45		
Vert. Vibration	1-16	1.84	.38	1.01	1.46		3.65		

TABLE 22.5b CONFIGURATION M

$n = .46$

$V_{M_F} = 104.42$ MPH





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2. Contract DA 44-177-TC-828

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2. Contract DA 44-177-TC-828

configurations were tested in the NASA Langley Full Scale Tunnel and two of these were tested to higher speeds and full scale Reynolds number and Mach number utilizing Freon-12 in the NASA Langley Transonic Dynamics Tunnel. A principal focus of the program was the decoupled or "matched blade" type of rigid rotor. In a "matched blade" the in-plane bending stiffness is equal to the vertical bending stiffness. It was demonstrated to simulated air speeds of 240 mph that this type of rotor is stable with extremely small values of control gyro inertia.

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